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Forthcoming Events.

MAY 1.

British Foundrymen's Association (Birmingham Branch).—Annual General Meeting and Smoking Concert.

British Foundrymen's Association (Lancashire Branch).—"Foundry Problems," by Mr. Penlington.

MAY 8.

Birmingham Metallurgical Society.—"Some Properties of Clays," by J. W. Meller.

MAY 22.

British Foundrymen's Association (Birmingham Branch).—"Mechanical Testing in the Foundry," by F. J. Cook.

NOTES AND COMMENTS.

The Imperial International Exhibition.

It will come as no surprise to those who last year visited the Franco-British Exhibition at the "Great White City," Shepherd's Bush, to learn that the buildings and other facilities which contributed so much to the success of the Exhibition are to be requisitioned this year for an International Exhibition. It would have been a pity to leave unutilised such facilities for gathering together and displaying the products of different nations and colonies, for the educational value of such exhibitions will not be questioned. As might be expected, the metallurgical and kindred sections will be well to the front in this year's exhibition, which will be opened about the middle of this month. Committees have been formed to advise the administration as to the formation and arrangement of special group exhibits relating to mining or metallurgy or to both. These committees, which consist of men representing the whole range of mining and metallurgy, are organising special exhibits of purely scientific or general public interest, and they are desirous that the "Trade Exhibits" should also be specially grouped together when possible, so that visitors to the Exhibition may find their work facilitated and may obtain a more comprehensive knowledge of the subject in which they are interested, and of the exhibits relating to it than would otherwise be the case.

Projected Exhibits.

Among the exhibits which are in hand or under consideration, may be mentioned:—(1) Electric furnaces at work on a small commercial scale and for laboratory purposes, models, working drawings, photographs, exhibits of ores and materials used in and of products from the furnaces. (2) Electro-magnetic and electro-static separators for ores, etc., on similar lines to the last-named exhibit. (3) Metals and alloys, special tool steels, etc., white metal, bronzes, and other alloys. (4) Metallurgical furnaces for solid, liquid, and gaseous fuel, including smelting, calcining, and other reverberatorie furnaces, cupolas, blast-furnaces, converters, etc. (5) Refractory materials for furnace linings, crucibles, etc. (6) Briquetting and agglomerating plant for ores and fuel. (7) Coke ovens, etc. (8) An assay laboratory in which sampling, crushing, grinding, screening, and other laboratory machines, furnaces, crucibles, etc., will be shown in operation. (9) Special exhibits illustrating local industries, etc., including:—(*a*) Cornish tin, wolfram, uranium, and other mining and smelting operations. (*b*) Welsh tinplate industry, etc. (*c*) Birmingham and Sheffield metal industries. (*d*) Several special exhibits illustrating the gold and other mining and metallurgical industries of our Colonies and dependencies.

With such a comprehensive collection of exhibits there will not fail to be much to hold the interest of foundrymen in general. But at the same time we should like to see the foundry trades more definitely represented than they were at the Franco-British Exhibition. There were certainly some remarkable examples of foundry work to be seen, but we do not think that the specimens which were shown at random

amongst the numerous other products of our iron and steel works gave anything like an adequate representation of the part that the foundry plays in our industrial life.

Malleable Cast Iron.

Perhaps in no branch of the iron-founding industry has so much disappointment been experienced as with the production of malleable castings; and even to-day, when every youngster is at liberty to revel in treatises and works on the chemical constituents of ordinary cast iron and the purposes they serve, the question of malleable casting retains its veil of semi-mystery and uncertainty. The truth is, malleable cast iron does not receive the attention it deserves, either at the hands of the engineer requiring castings or the student engaged with foundry topics. There are so many uncertainties involved in the production of the work—for the average producer of such castings has so little knowledge that he cannot place his procedure on any sounder basis than practice and the success attained thereby—that an inevitable distrust exists in the minds of many people regarding the art. That in the earlier days of the history of malleable cast iron little attention was paid to it except by only a few, is evidenced by the fact that in 1804 Samuel Lucas, of Sheffield, obtained a patent for "a method of separating impurities from crude or cast iron without fusing or melting it, and of rendering the same malleable, etc.," the method in question being actually the process discovered by Réaumur nearly one hundred years previously. It was in 1722 that that famous French chemist announced his discovery that by heating iron castings packed in red ore they were softened more readily than by any other means; but it had received so little attention that in 1804 Lucas patented practically the identical process as a new idea. It is encouraging to note, however, that while the trade in general has given so little attention to the progressive side of the work, a few students, such as Hatfield and Longmuir in England, and Dr. Moldenke in America, have seriously undertaken the study of the subject. It is quite within the bounds of probability that a very few years will see such advances made that the old and troublesome process of annealing, around which centre the majority of the difficulties of the trade, will be condemned and consigned to the limbo of obsolete practices. There have been several attempts to produce unannealed malleable castings on a commercial basis (which, of course, is a very different thing from production as a laboratory experiment), but with characteristic reticence the foundry world has refused to accord much credit to the claims put forward by the operators. We have, however, recently published particulars of one of these processes which appears to have justified its claim to a commercial standing, at least under some conditions.

In many respects the term "annealing" is a misnomer for the process which the castings undergo, for there are other essentials involved besides the annealing. The latter could be accomplished by the action of heat only, without the aid of the surrounding ore or other material in which the castings are packed. The actual action of the malleablising process as practised to-day consists in the conversion of an iron of special composition into practically a steel through the elimination of part of the carbon; whether this reduction and any other alteration of the constituents is effected while the metal is in the molten state or after it has assumed a solid form is immaterial, except from a point of expense in producing the effect, provided the resulting casting is the same. The modifying of internal strains, which is credited to the heating during annealing also constitutes a feature to be regarded, though some of the non-annealing processes referred to (where the reduction or alteration of the constituents is effected while the metal is molten) claim that such after-heating to relieve internal strains is unnecessary. Concerning the process of production as commonly practised, the essential requirements are first suitable materials, and then a sound comprehension of the process in all its details. We cannot help thinking that a good many of the failures that are recorded in the production of malleable cast iron are due to sheer ignorance of the true nature of the material.

The Electric Furnace.

Neither in the reduction of ore nor in the melting of iron and steel for casting purposes has the electric furnace been adopted in England to the extent that its success in other countries (and in this country also, where it has been tried), would seem to justify. There are many reasons to account for this. In the first place, the use of the electric furnace has not long been out of the experimental stages; in fact, in many respects it is still in the experimental stages, though it has been proved beyond all doubt that it stands as one of the best, if not the best, medium for producing molten metal. But there are many points, particularly in regard to economy, that have yet to be satisfactorily settled before the electric furnace will make great headway in England. We have not the natural supplies of water-power for the generation of electrical energy that have enabled America and some countries on the Continent to adopt the electric furnace, and until there is presented some other means of meeting this difficulty we are hampered. The suggestion that waste blast-furnace gases should be more generally employed for this energy-generating has much to commend it, for where it has been adopted it has given satisfactory results. In this connection we may say that in many other departments there are continually lost immense quantities of heat and heat-generating gases that might be turned to account. The question of the conservation of waste energy is, however, receiving increasing attention from the heads of some of our largest firms, so we may hope in the near future to see some alteration in the general attitude to the question. It should not be long, either, before the electric furnace finds its place in all our large works, for the advantages it affords, particularly as regards the purity of the metal produced and the accuracy of control over the constituents, are such as to recommend it to all who require first-class metal for casting and such like purposes.

British Foundrymen's Annual Convention.

The annual meeting of the British Foundrymen's Association will be held this year at Birmingham, on August 3, 4, and 5. The programme includes the reading of the following papers:—

"Twenty-five Years of Cast Iron," by Professor T. Turner, M.S.C., A.S.S., R.S.M., Birmingham.

"Influence of Chemical Compounds on the Properties of Cast Iron," by A. H. Hiorns, Principal of the Metallurgical section Birmingham Technical School.

"The Production of Patterns for Light Castings," by W. H. Sherburn, Warrington.

"The Application of Rule-of-Thumb and Science in the Foundry," by Sidney G. Smith, Chesterfield.

"The Cupola," by H. Emberton, Derby.

Visits to works in the district will also be arranged, and the Convention promises to, if anything, surpass previous ones in interest. The preparations are approaching completion. The Local Committee has been strengthened by the addition of prominent local metallurgists, and in addition to the Branch Council, the following gentlemen have been co-opted:—Professor T. Turner (Birmingham University), Messrs. A. H. Hiorns (Technical School), W. J. Foster (President, Staffordshire Iron and Steel Institute), and H. Winterton. Of the Local Committee, Mr. C. Heggie, the Secretary of the local Branch, has been appointed Secretary.

Malleable Cast Iron.

British Foundrymen's Association.—Birmingham Branch.

At a meeting of the Birmingham Branch of the British Foundrymen's Association, on March 27, MR. J. MATTHEWS, of Walsall, read a paper on the subject of "Malleable Cast Iron."

In a few preliminary remarks on iron from the historical point of view, the lecturer said that as founders they were convinced iron was the most valuable metal they had, and their ancestors found out very early that they could produce the metal by taking red earth and smelting it with charcoal. Although the discoverers were unable to deal with it in the modern fashion in the foundry they managed to forge it into various shapes. The early Britions, prior to the Roman invasion, smelted it in the Cheviot Hills by means of a natural draft. At a later date the Spaniards also melted iron in the Pyrennees by means of an excavation in the earth, the draft being ingeniously produced by allowing water to fall down a vertical pipe from which air was being drawn. The air which accumulated at the bottom of the pipe was conducted to the hearth for the purpose of smelting the iron. The next development was the Osman furnace, by means of which the nature of the iron was changed owing to the longer period during which the iron was in contact with the heat, and became hard and brittle through the absorption of a certain amount of carbon. This ushered in the era of the blast furnace.

Pig-Iron for Malleable Work.

With regard to malleable cast iron, that was defined in rather crude terms by the Iron and Steel Institute as: "An iron which when first made is quite in the condition of cast iron, and is made malleable by subsequent treatment without fusion. Although the English name of this variety suggests that it is cast iron, it is not truly a variety of cast iron, because it lacks the essential properties of cast iron, namely, its extreme brittleness." This definition, the lecturer said, scarcely defined malleable cast iron in its true character, because they all knew that cast iron was stronger under compression than wrought iron, and malleable cast iron possessed all the essential qualities of cast iron. English malleable cast iron was made from special brands of hematite pig-iron, smelted from a pure, rich, Cumberland ore. Most of the carbon should be in the combined state, and the percentage of sulphur and phosphorus should be low, but, if possible, there should be a fair amount of manganese. The ores used for the production of malleable pig by the Americans were of a purer kind, with a lower percentage of sulphur. The most common brands of English pig-irons took their names from the districts where they were smelted. There were also special brands in which the iron was indicated by the fracture. What was known as Swedish iron was of a rich character, and very suitable for malleable purposes. Other descriptions were slightly mottled irons, which had the pure carbon separated out in a graphitic state. Then there were the grey, the mottled white, the hard and soft, and the speckled. At this point the lecturer exhibited the following table of principal malleable irons:—

Analyses of Malleable Pig-irons.

	C.C.	Graphitic C.	Silicon.	Sulphur.	Phosphorus.	Manganese.
	P.cent.	P.cent.	P.cent.	P.cent.	P.cent.	P.cent.
Swedish Pig ...	3.400	—	1.100	0.030	0.020	0.170
American ,, ...	2.750	—	0.700	0.070	0.120	0.300
English ,, ...	3.500	—	0.320	0.049	0.040	0.135
Mottled White ...	3.800	0.25	2.000	0.015	0.200	0.500
,, ,, ...	2.680	0.38	0.460	0.048	0.045	0.200
Lorn. (White) ...	2.820	0.10	0.118	0.004	0.070	0.180
,, (Mottled) ...	1.500	1.82	0.530	0.004	0.070	0.050
,, (Grey) ...	0.950	2.32	0.522	0.007	0.071	0.216

With regard to this table, the lecturer pointed out that in the Swedish iron the combined carbon was fairly high, while graphitic carbon was absent; sulphur and phosphorus were low. That was a very good pig, often used where a good class of malleable iron was required. The American brands referred to were white irons, afterwards converted into what was known as the "Black Heart." Again graphitic carbon was absent, but there was a fair amount of combined carbon, of silicon, and of sulphur, the latter being slightly higher than in the Swedish. The same was true also of the phosphorus and the manganese. With regard to the English iron, of which the name was not given, that was recently referred to by Mr. Adamson at the South Staffordshire Iron and Steel Institute as a very good pig for producing a malleable casting. Both this and the following one were mottled white, and were Cumberland pig-irons. The Lorn examples were considered superior to the other English samples, because the sulphur was so low. The opinion was recently expressed by a merchant with whom he had discussed the question that sulphur made no difference to the annealing, but experienced malleable makers knew that was quite a mistake.

The Reaumur method was generally employed in the manufacture of malleable castings in England, while the American method was known as the "Black Heart." He would call special attention to some samples furnished him by Ley's Malleable Castings Company, Limited, Derby. The firm informed him by letter that what was known as American "Black Heart" was not exactly American iron, but that the term was really a special trade-mark, by which American iron was put on the market.

So long since as the year 1722, it was discovered that a very white hard special brand of pig produced a satisfactory malleable iron. Although that knowledge was public property for anybody who chose to use it, it was not till eighty years afterwards that the metal was actually manufactured, when a Sheffield maker named Lucas systematically produced it. His brother Thomas, working at Chesterfield, carried the process to still greater success.

Patterns for Malleable Castings.

With regard to patterns, there were some important points to be noticed. They must remember that in connection with malleable iron there was a greater shrinkage than with common cast iron, and they would incur trouble unless the pattern was proportioned accordingly. As much as three-sixteenths of an inch to

the foot shrinkage in the process of annealing had been experienced, but in some cases, especially with the American iron, it was said that there was an increase of area instead of a shrinkage. He had not found that in his experience.

The pattern-maker often got blamed for matters where he was not responsible. It was a mistake to make the pattern the proper size for malleable castings. For patterns in which a soft metal was necessary, they generally used lead with a small amount of antimony. Aluminium was also used, and so to a less extent was wood. Where a number of castings were to be produced they used brass. They had to be very careful in proportioning the sections of the pattern. It was very essential to be more careful in the treatment of corners, and they were very well aware that where crystallisation occurred, the corners were the weak spots. The crystals had a way of arranging themselves so as to weaken the corners, making the angle spongy.

The lecturer exhibited at this stage two bars, showing the peculiar arrangement of crystals. After being annealed twice, there was a contraction of the metal and oxidisation in the centre.

Moulding.

With regard to moulding, the articles were generally moulded in green sand. It was unnecessary to go into details, but much the same method of moulding was employed for malleable iron as for ordinary cast iron. For specially large castings, the floor method was employed. Then there was what was known as the odd side method, in which the odd side was sometimes made in sand and sometimes in plaster of Paris. If a large number of the article were required the odd side was usually made of cast iron, and then were employed what were called "Williamson's Plates." The patterns for such articles as cylinders would be made in two halves and then fastened together. If the articles were of a large diameter they were fitted together so that one side turned over another. By making one side large, a number of articles could be moulded, and that was apparently the origin of the term "odd-side." If a still larger quantity were required, they were made upon a plate. Another method of moulding for small castings was the "stump" or bench moulding. In that case, the box or bench mould was made in such a way that one corner hinged on to the opposite corner, so that it could be taken away and used to make another set.

Melting Temperature.

Dealing next with the question of melting, the lecturer said the casting temperature of malleable iron had a very great influence on the class of work produced, and it was clear there was a certain temperature which would give to iron the greatest strength. Away from that temperature in either direction the iron became weaker. If the iron was too cold, it was found that the sharp outlines and thin parts came out defective, while if it was too hot the work was spongy in parts and contained blow-holes. Aluminium was very useful in producing a sound casting, for it had been found that if before the metal was tapped into the ladle a small amount of aluminium was placed therein, and the metal poured upon it, any dirt or kish that might be contained was liberated and formed on the surface, while any gases contained were also liberated.

With the object of illustrating the effect of temperature, the following table was shown, illustrating that the best casting temperature for malleable iron was 1,230 degrees Centigrade:—

Influence of Casting Temperature.

Analysis.						Mechanical Properties.			
C.C.	Gr.C.	Si.	Mn.	S.	P.	Cast Temp.	Elastic Limits. Tons per sq. in.	Max. Stress. Tons per sq. in.	Elongation per cent. in 2 in.
As Cast. Unannealed.									
3.4	,,	0.39	0.05	0.02	0.02	1320	—	10.7	—
,,	,,	,,	,,	,,	,,	1230	—	15.9	—
,,	,,	,,	,,	,,	,,	1120	—	12.1	—
Annealed 100 hours in Ore.									
0.2 to 0.4	3.2 to 3.2	,,	,,	,,	,,	1320 1230 1120	20.0 24.3 22.5	20.6 20.2 26.5	1.0 3.5 2.0

For example, whereas iron cast at 1,320 degrees showed a maximum stress of 10.7 tons per square inch, iron cast at 1,230 had a maximum stress of 15.19. In one sample exhibited, the effect of annealing for ten hours in ordinary ore reduced the combined carbon from 3.4 to 0.2 per cent., and in another case to 0.4. In another case annealing raised the maximum stress from 10.2 tons per square inch to 20.6. That was secured from iron melted at what was considered the proper temperature of 1,230 degrees C. In another case the elastic limit was raised from 20 tons per square inch to 24.3 tons, and afterwards dropped to 25.5. The highest elastic limit was clearly associated with the temperature of 1,230, and the maximum stress was also the maximum elongation. It was important to notice that it was impossible by annealing to rectify any mistake made in the melting.

In the early manufacture of malleable cast iron in England and America, the only method employed to melt the metal was the pot furnace, and the castings made were of the best kind. In most districts it was the method which gave purer and stronger iron, because the impurities in the coke did not come into direct contact with the iron, and the sulphur and phosphorus in the coke were, therefore, not detrimental. The pots were generally made of plumbago, holding about 60 lbs. of metal, made up of about 46 lbs. of pig-iron and 14 lbs. of scrap, and, on an average, 35 lbs. of coke was required to melt the metal.

By way of illustrating the crucible method, views were exhibited showing the method in operation at Messrs. Smith's establishment, Sheffield. Other slides represented the work in operation at the foundries of Firth & Sons, Sheffield, and the Whiting Foundry, America.

The next method of melting most commonly employed, continued the lecturer, was that of the ordinary cupola. It was very necessary to exercise care in dealing with the cupola in regard to fuel, because the cokes must be of the purest kind, and especially low in sulphur. The best brands on the market were the Derbyshire, Durham, or the North's Navigation coke, or, indeed, any other coke which was hard, and had a low percentage of sulphur and phosphorus. On an average, about 40 lbs. of coke were required to melt 100 lbs. of metal by the cupola method.

A still further method was the open-hearth process and the reverberatory air furnace. Where large supplies were wanted this class of furnace was more economical than the pot furnace, and had the same merit that the impurities in the fuel did not come into direct contact with the metal. The larger apparatus were much more largely used in America, but they were coming into much more general use in this country, in the larger foundries. The fuel used was a very

hard bituminous kind of coal, of which 25 to 30 lbs. was necessary to melt 100 lbs. of metal.

With regard to the approximate cost of melting in the crucible, it was £4 10s. per ton, and in the cupola £1 3s. 6d., the calculation being based in both cases upon a coke expenditure of 32s. 6d. In the air furnace, the cost was 15s. 6d. per ton, with coal at 10s. At the same time, said the lecturer, he would like some criticism of those figures. He understood that a small converter, known as the "Baby Converter," was largely coming into use with the Americans. The blow proceeded as in the production of mild steel, except that all the silicon was not burnt out, but when it was sufficiently low, the blast was stopped and a small quantity of aluminium was added to the metal making it more fluid and more suitable for pouring into the mould.

At this stage, the lecturer exhibited views of the reverberatory furnace, calling special attention to the employment of bungs, which have the effect of protecting the metal.

Annealing.

By way of illustrating the effect of the annealing, the lecturer took a bar of iron, which smashed into fragments with a light tap on the table, and the same bar after annealing was bent easily into the shape of the letter U, with practically no external change. The fracture of the bar showed an entirely white surface, all the carbon being in the combined state. The contraction due to the cooling of malleable iron, it was explained, was much greater than with common iron, and if the sections were properly proportioned rupture would certainly occur through the light parts first solidifying, and then the iron would be pulled asunder through the contraction taking place in the larger chills. Among the ingenious methods employed to prevent this were the use of chills, crushing cores, and occasionally the bending of the pattern. Another method to overcome internal bending was that known as "firing" the casting, which consisted in placing them when sufficiently solidified in a muffle which had been heated to about 800 degrees Centigrade, and then cooled down, after which they were ready for annealing. While the firing relieved all internal strains caused by the cooling, the castings were still in their hard state and would snap off quite easily.

With regard to the actual process of annealing, the lecturer dealt in detail with annealing ovens, ordinary ovens, draw ovens and case ovens. The process consisted of placing the hard castings in iron boxes and then surrounding them with red hematite ore. The boxes consisted of pans and rims made generally of a mixture of pig-iron and malleable scrap, and in shape round, oval or oblong, to suit the class of work. Some were pans, others were simply rims of metal, and might be placed one on top of the other, so as to accommodate themselves to the castings, which might be of any length. The top rims were covered with lids and the joints between each pan, the rim, and the lid, were carefully luted with a sand to prevent the heat of the fire from coming into direct contact with the castings. The pans were sometimes filled while in the ovens.

The oven might be fired with coal or gas. One end was left open and afterwards bricked up when the oven was filled, and then made tight with the grouting of sand. In one or two places, however, the bricks were left out to enable the temperature of the furnace to be observed. Generally, the heat of the furnace was a bright cherry red, and a proper temperature for successful annealing was 1,000 degrees C., although the temperature of the work itself was about 200 degrees below this. The lecturer had known one or two cases where the temperature had been about 1,025 degrees. The proper length of time for the annealing was about 100 hours, according to the class of work, and the amount of sulphur, etc., present. Various means, such as test cans, balls of sand and Seegar's cones, were used to test the proper length of time, but these methods were being displaced by the pyrometer, such as the Féry and also Callender & Griffin's thermo-electric pyrometer, which not only registered the temperature, but also showed whether the ovens had reached the proper temperature, and had been maintained at that temperature for the requisite time. In the annealing by Reaumur's method, the oxygen given out by the ore of red hematite combined with the carbon of the outside skin of the casting and passed off—a process indicated by the blue flame. The decarbonisation on the outer skin and on the inside gradually spread over the whole surface, which was changed from the combined state to the graphitic state. The sulphur and manganese retarded the annealing process very greatly. The American iron, which was very low in sulphur, practically had the whole of the carbon liberated, and the fracture, known as the "Black Heart," was obtained. Under Reaumur's method the carbon was not precipitated, but some of the carbon nearest the exterior combined with the oxygen of the ore and was burnt as CO. The other portions of the carbon passed outwards, and were to some extent eliminated.

Cleaning the Castings.

Dealing with the question of the cleaning, the lecturer said that sometimes the castings required a heavy hammer and plenty of muscle to release them from the pans, and they were then placed in wrought-iron cleaning barrels, to remove any ore still adhering. Where the barrel method would be injurious and might deform the casting, sand blast was used, while still a third plan, where there was danger of injuring the skin of the casting, was to pickle the casting, for which purpose they were placed in tanks in a liquid consisting of one part of vitriol and four parts of water. Another plan was to use hydrofluoric acid in the proportion of one part to ten of water, which solution dissolved the sand and left the iron unaffected.

As illustrating the secrecy employed by some iron-founders, the speaker mentioned that some time ago he was talking to a malleable ironfounder who was much elated over having found an acid which would clear the casting of sand. He was much astonished when he heard that the knowledge of this acid was very widely extended, and that he had really been experimenting with an acid which was a matter of general knowledge almost to the elementary student. It had been said that the malleable founders kept their secrets more closely than any other founders. If that were so, they lost a great deal more than if they gave out their knowledge and received other knowledge in return.

Discussion on the Paper.

The CHAIRMAN, in opening the discussion, said that the lecture was especially valuable, because it had come direct from the workshop. It was quite true that the remark had been repeatedly made that malleable founders were very secretive with regard to their knowledge, and he entirely agreed that by that policy they were losing more than they were likely to give away. He imagined that applied also to the brass and copper industries. Each man seemed to be moving in a little groove of his own, and appeared to be very much afraid that somebody might know what his groove was. The effect of that was that he was daily and weekly making mistakes which cost him a great deal of money. It would be a good thing

for the malleable casting industry when founders came into the open and explained what their difficulties were. They might, if they pleased, keep their successes to themselves. But he found that people were more apt to speak about their successes than their failures; and yet it was the failure that furnished the educative part in a man's life.

Mr. A. H. Hiorns said while the lecture was very interesting, they would have liked Mr. Matthews to have gone a step further and told them something about actual annealing, and the difficulties connected with it, which seemed the most important part of the subject. They knew that for the most part ironfounders had to deal with material of very impure character, and the very presence of those impurities tended to make the metal hard and unworkable. Malleable cast iron was an extremely valuable metal, because of its toughness compared with ordinary cast iron and its very high tensile strength and elongation. He did not know whether it would be possible in an ordinary cupola—possibly it would not—to have wrought iron scrap and carbon melted together, and so to form cast iron, but there were other furnaces in which such a thing could be easily done. Some few years ago Mr. Stead, of Middlesbrough, experimented with a round cast-iron bar, annealing it for a considerable length of time. Having taken a micro-section and examined the structure, he found a hard outside skin (if a thing was hard it was generally either brittle or tended to be brittle); inside was practically pure iron, from which the carbon had been burnt off by the oxygen; inside this layer of pure iron was a layer consisting of pearlite, and inside that again was some pearlite and graphite in the core of iron. Iron might be combined with carbon to form what was termed cementite, which was chemically combined together with a certain amount of iron forming a hardening carbon.

With regard to the construction of iron, they knew white iron did contract very considerably, but they were not all as clever as the American ironfounders, who produced expansion as well as shrinkage. Mr. Matthews' suggestion that the shrinkage was three-sixteenths of an inch to the foot was only a sort of general statement in regard to which they would like to have rather more exact particulars. No doubt the shrinkage would vary very considerably under different conditions. He believed that in malleable work it was the wisest policy to expose as much surface as possible to the action of the hematite. Formerly, it was stated that oxide of iron, consisting of iron and oxygen, acted upon carbon in the cast iron, and that the oxygen, taking the carbon which went off as a gas, left the iron free from carbon, the malleable iron consequently being pure iron. That idea had been completely exploded. The action of oxide of iron was only a partial action on the outside. The oxygen did actually unite with the carbon to remove it, and so they had a layer of iron in a crystalline state. A good deal of the value of malleable iron was due to the fact that high-class pig was used. It was commonly supposed that silicon was a disadvantage, and he thought it ought to be absent, as it apparently offered no advantages. As to phosphorus and sulphur, they ought to be extremely low, although in the presence of manganese some sulphur would unite with the manganese, but that would be only neutralised and not taken away. Phosphorus might be useful with regard to the metal melting easily within the furnace, but in the casting itself phosphorus was a disadvantage, and should be absent. The ideal iron should be practically iron, carbon, and manganese.

As to the furnace employed, he understood that the cupola was a very bad furnace indeed for malleable castings, and the air furnace was better. But he found from inquiry, that malleable ironfounders were using the Siemens regenerative furnace for that work, and it was only the very high cost of this which prevented it being more largely adopted. He should imagine that the open-hearth furnace had a great future for malleable work where castings were wanted in large quantities.

Mr. W. B. Parker (Rugby) said his own experience of malleable iron had been chiefly in the testing of it. In the engineering trade the value of malleable iron was that it came intermediate in its physical properties between cast iron, which gave 12 tons to the square inch, and steel castings of 28 to 30 tons per square inch. The average tensile strength of malleable cast iron would be about 18 tons, but there had been a process developed in Sheffield by Mr. Hatfield, who claimed to be able to get from 20 to 23 tons per square inch maximum stress, with the enormous elongation of 15 to 19 per cent. on 3 in. That was, indeed, enormous for malleable cast iron. He had not seen samples of the material, but he was told that the difference in price between that and steel, with which it might be able to compete in some respects, was not very great. There had been a great deal of work done in Birmingham in the study of malleable castings. A gentleman, George Parker Royston, in 1897 did a great amount of research at Mason College on the reaction, and he was the first to draw the distinction between the old process and the "Black Heart" process. The great point was to exclude the air, and for that purpose lime or sand, or anything of that sort, could be employed, and they had merely to raise the temperature to the point at which the carbon would change from the combined state. In the Réaumur process there was a considerable loss of carbon, especially on the outside, and the disadvantage of that was the high oxidation. With regard to silicon, it was not altogether disadvantageous, and it was necessary to have some present to have a sound casting. Moreover, the silicon aided the conversion of the carbon into temper-carbon. Phosphorus was bad, and in spite of the annealing it would probably be there in combination with iron. Manganese retarded reaction, for it raised the critical point at which conversion took place. In conclusion, the speaker asked the lecturer if he could give any information as to the use of nickel. There would be a great scope for such an alloy if it could be made effective.

Mr. D. Pulley said there were many ways of annealing, for example, in asbestos or on a blacksmith's hearth. The old idea of the oxygen combining with the carbon had long been exploded. He believed the application of heat in the process of annealing in a close chamber eliminated the carbon. A previous speaker had suggested that it did not eliminate it; it merely changed its form. Personally, he had heard a lecturer say that carbon was eliminated in the "Black Heart." He (the speaker) believed there was no law to cover the question of contraction. One thing would contract more than another, and it was found that casting temperature had great effect. The great defect of the Siemens furnace was that it was very costly. With a crucible the output was limited. There was more difficulty in the selection of the iron for malleable castings than for ordinary ones, and, also, sellers required fancy prices for malleable irons. Annealing was undoubtedly a great art, and he believed that the opportunities of individual progress gave the greatest incentive to excel in it. He was inclined to agree with the man who said that iron lived and breathed and absorbed what it liked best. Undoubtedly, it had some remarkable affinities, and one had to keep certain things away from it if the iron were to be wholesome and satisfactory results obtained.

Mr. J. R. McCallum said that with regard to expansion, he had come across a very peculiar development. He was recently dealing with an ordinary ring, some 8 in. in diameter, which in the hard state was one-eighth of an inch under the size of the pattern. After it had been annealed for the ordinary length of time, it came back to exactly the size of the pattern, so that it had expanded during annealing. On another occasion they were dealing with castings about 2 ft. long, which at first contracted to one-eighth of an inch while they were kept in a vertical direction, but when placed lengthwise and annealed on the flat they attained the same dimensions as the pattern. There were many points in connection with contraction and expansion which seemed to call for explanation.

Mr. A. Harley said an impression had been conveyed that annealing was a very difficult art. That was probably true with a top-fired furnace, but the matter was different with a gas-fired oven. There was no difficulty at all with an ordinary producer oven properly regulated by somebody who understood combustion and used pyrometers. There had been some controversy as to the function of silicon. He had himself made hundreds of analyses, and he found that the best malleable iron contained 0.6 to 0.7 per cent. of silicon. He was inclined to agree with Mr. Parker that to secure soundness they must have silicon present. He was referring more especially to light castings, such as were used in the motor trade. He considered that sulphur and phosphorus should be absent. Some people thought light castings could not be run without phosphorus, but it was possible with just a little manganese. With regard to carbon, he had found that it was possible to have it too high. He had found a satisfactory proportion at about from 3 to 3½ per cent.

The Chairman said he was glad that Mr. Parker had referred to the investigations of Mr. Royston, who many years ago made a number of experiments with cast iron. That was probably one of the earliest attempts to put a very old industry on a scientific basis. Royston applied the pyrometer as recommended by one of the speakers. His own view was that the pyrometer was a very necessary aid to the malleable trade, and he was astonished that makers would go on risking their castings in employing the workman's eye as the test of temperature when perfected pyrometers were available. The pyrometer was coming more and more into use in foundries for the testing of heat during annealing. A well-known ironfounder had assured him that he was using gas for annealing with very great advantage; not so much from the point of view of economy as compared with coal, as on the ground of regularity of temperature. He had applied the pyrometer to the coal-fired furnace and he very quickly found irregularity.

With regard to melting, somebody had suggested that malleable iron made in cupolas was rather doubtful stuff. Probably it was made for a certain market which did not believe in paying too much money for its goods. Personally, he had examined many castings made in cupolas, and they showed very good quality, in view of the fact that the metal was in contact with the fuel. With regard to the Siemens furnace, there was in Walsall in operation a Siemens furnace producing malleable cast iron, doing very satisfactory work, and producing first-class material. Such troubles as they had came principally from the difficulty of getting a satisfactory bottom rather than the difficulty of melting the iron. There was no doubt that for working on a large scale the reverberatory air furnace was the most advantageous.

With regard to silicon and manganese, he believed that the American founders stipulated for so much silicon and so much manganese, and the reason was understood to be that with a certain amount of manganese present they got a casting very much cleaner after annealing than otherwise.

He proposed a hearty vote of thanks to the lecturer, and this proposition was carried unanimously.

Mr. D. Wilkinson said that his connection with the malleable trade covered a period of about forty years, and according to his experience, results were apt to be erratic. He had had castings turned out as tough as leather, and others similarly treated had come out unsatisfactorily. Malleable iron foundry he believed to be still in its infancy..

All the iron he had passed had been tested by the eye; yet he had never burnt the oven, although, as was no doubt the case with other ironfounders, he had had to return portions of the work to the oven. There was no doubt the pyrometer would keep them right. But they must first find out what temperature they wanted. There were castings which required 200 hours, while others would do with 80 hours. With regard to elongation, he had seen castings grow considerably. He had seen one grow first one-eighth of an inch and then another eighth of an inch, and he could not say how much further it might have gone. (Laughter.) He knew something about the production of the American "Black Heart," and if they got some of the American iron mixed with English iron they would get the "Black Heart" all right.

Mr. Matthews, replying to the vote of thanks, said his main reasons for giving the paper was because of the statement that malleable ironfounders would not give out their ideas. He wished to acknowledge the assistance he had received from Mr. Bray, and also from Ley's Malleable Castings Company, Limited, of Derby, who had furnished him with a number of samples with certificates of tests from the Sheffield testing house. He had also been greatly assisted by Mr. MacFarlane. He hoped when experiments were further advanced to be able to place further particulars before them. One method of making malleable iron was that described by Americans as the method of the "Baby Converter." By this method nearly all the silicon and phosphorus were blown out, and aluminium was added to make the metal fluid. With regard to nickel, he personally had had no great experience with that metal.

Buenos Ayres Railway and Land Transport Exhibition.—An International Exhibition relating to railways and land transport generally is to be held in Buenos Ayres next year, and manufacturers of all countries who are in any way interested are invited to participate. The Exhibition opens on May 25, 1910, and closes on November 25 of the same year. It will be divided into seven sections, each consisting of a number of groups, and is intended to amplify the latest developments in railways and tramways, electric and otherwise; automobilism; cycling; post offices, telegraphs and telephones; horsed vehicles, etc.; military and other departments of transport, and all its numerous accessories. The exhibition is to be held in connection with the hundredth anniversary of the independence of the Argentine Republic.

The annual meeting of the American Electrochemical Society will be held in Niagara Falls, Canada, on Thursday, Friday and Saturday, May 6, 7 and 8. A special feature of the meeting of particular interest will be a symposium of papers on the electrometallurgy of iron and steel. The whole of the first day will be devoted to this subject, papers being promised by Dr. Eugene Haanel, Dr. Paul Heroult, M. Paul Girod, Dr. F. A. Kjellin, M. C. A. Keller, M. Gustave Gin, Mr. R. Turnbull, Captain Ernesto Stassano, and Mr. F. A. J. FitzGerald. Other fields of electrochemistry will, however, not be neglected.

Gear Wheel Moulding Machines.

By Arthur Greenhalgh.

It is proposed by the author to consider machines which are in principle dividing machines, fitted with necessary adjustments for the moulding of the teeth of wheels, the arms, etc., of the wheels being produced apart from the machine by means of cores in the usual manner. With the class of machine mentioned, the chief advantage lies in the equal pitching of the teeth and the economy of making a tooth block, core box and striking boards, as compared with the cost of a complete pattern, which would otherwise be employed. This economy is obviously dependent on the number of castings to be made, for when a large number of small wheels are required, the cost of a pattern would be small compared to the expense of moulding in a machine. In the case of large wheels, of which one or two castings only are required, the economy of a machine for producing the moulds is considerable, but small wheels required in quantities are better made from machine-cut patterns on an ordinary moulding machine. Those of medium size go to either, the choice depending chiefly on the number required.

The clean withdrawal of parallel teeth, ensured by the stripping plate in the common moulding machine using complete patterns, is provided for in the wheel moulding machine by a stripping bit held on the sand. The older practice was to employ two teeth for moulding from, one tooth space only being rammed at a time and the block being moved round a distance equal to the pitch between each ramming. But three teeth, or even more, are now used, and the number of lifts and removes reduced. The earliest wheel-moulding machine made was the invention of Mr. P. R. Jackson (1855). It was of the table type, comprising the essential elements of the modern machines. Scott's machine was introduced about 1865, and was a favourite for many years; but being a pillar machine, it lacked the rigidity of machines having the broad base afforded by beds and tables. Also it provided no provision for moulding wheels on a table. Every mould had to be made in the floor, the workman kneeling; and as the pillar was 6 in. in diameter, no pinion smaller than about 8 in. could be made on it. The machine also had to be lifted out of its step and taken away before a mould could be cored up and cast. The table machines are free from these disadvantages; moulds are rammed up on the table and removed for coring up. Yet since large wheels are better moulded in the floor, either separate machines are used, or the dividing mechanism is made capable of use either on the table or on a floor base.

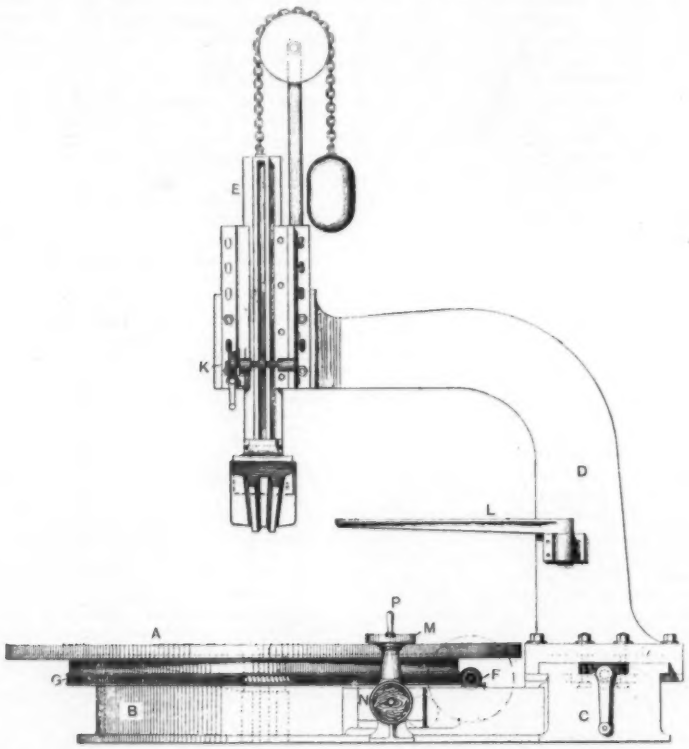


FIG. 1.—MESSRS. BUCKLEY & TAYLOR'S APPARATUS AS A TABLE MACHINE: ELEVATION.

Of the present types of table machine I will select two for description, the Buckley & Taylor and the Whittaker.

The Buckley & Taylor apparatus is adapted for use either as a table machine, Figs. 1 and 2, when it can be used to mould in boxes, or as a radial arm machine, Figs. 3 and 4, when it is used for moulding on the floor. The apparatus in these forms can produce wheels from 25 ft. down to 6 in. in diameter.

When using the table machine the table A is carried on a pivot in the base B, to an extension of which the bed C is bolted. The transverse movement of the arm D along the bed is the means by which the adjustment for radius is affected. (In the Scott machine this adjustment was made by the radial movement of the arm, which on long radii produced unsteadiness when lifting and lowering.) The slide E

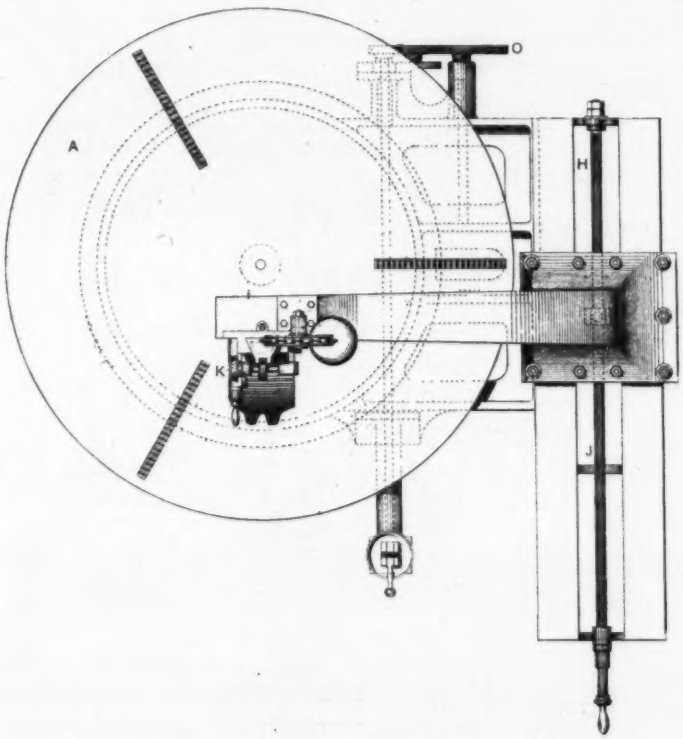


FIG. 2.—MESSRS. BUCKLEY & TAYLOR'S APPARATUS AS A TABLE MACHINE: PLAN.

by vertical motions lifts and lowers the tooth block at its lower end, and is counterbalanced at the other by a suspended weight. The table A is rotated by a worm gear, F, G; the arm D is traversed by the screw and hand-wheel H, and clamped by the screws in its base when making vertical lifts. For horizontal withdrawals, as in worm wheels and helical wheels, a stop is provided to reset the arm by. Worm and spur wheels actuate a rack on the vertical slide E. The moulding boxes are centred by the radial racks in the face of the table, shown in the plan, Fig. 2. Attachments are provided at L for the moulder to lay his tools on. Holes are provided in the table for the insertion of a sling chain for lifting and lowering the table by, and when a small wheel is being moulded, these are filled with blocks of wood to give a level face. The dividing or pitching mechanism which is common to all machines, comprises the worm F and wheel G; the division or notch plate M having four notches at angles of 90 degrees; the wheel N on the handle shaft, and the wheel O on the worm shaft, N and O being connected by an idler on a swing plate. The notches in the plate M permit of setting the exact number of turns. If the numbers of teeth on N and O are equal, and one turn around the notch plate is given to the handle P, then the wheel being moulded would obviously have the same number of teeth as the worm wheel G, or 180 teeth. For all pitchings the rule is:—As the number of teeth in the worm wheel G is to the number of teeth in the wheel to be moulded, so is the number of teeth in the wheel N required on the handle shaft, to the number of teeth in the wheel O required on the worm shaft. If the result is in the form of a fraction multiply it by any convenient number to produce a whole number of teeth, and use the same figure to multiply by for the turns to be given to the handle P in the division plate.

The essential difference between the apparatus as a table machine and as a floor machine is that the latter has a foundation ring fitting on a permanent base. The ring receives the base and table from the machine as shown in Fig. 1, and the table then receives a guide and a radial arm by which adjustment is made for diameter. Similar reference letters denote identical part in Figs. 1 to 4.

The Whittaker machine is convertible by means of an extension slide to mould wheels from 3 in. to 30 ft. in diameter. The peculiarity of the machine is that the radius is adjusted neither radially nor transversely, but by slewing the pillar that carries the

arm around the axis of a hollow socket, within which it fits. This involves an arrangement of the tooth block carried different from that in any other machine.

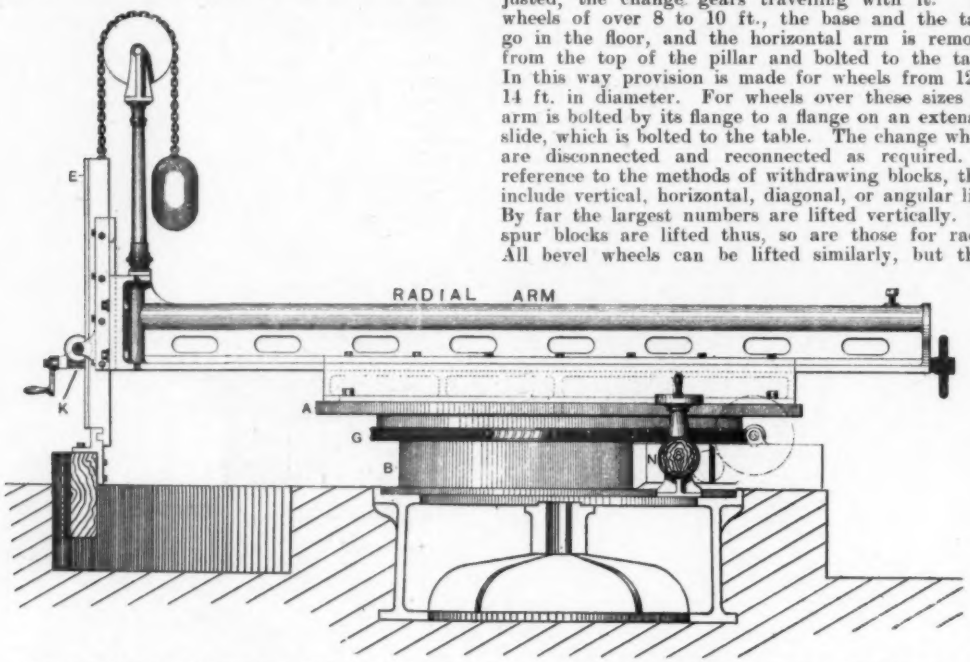


FIG. 3.—MESSRS. BUCKLEY & TAYLOR'S APPARATUS AS A FLOOR MOULDING MACHINE: ELEVATION.

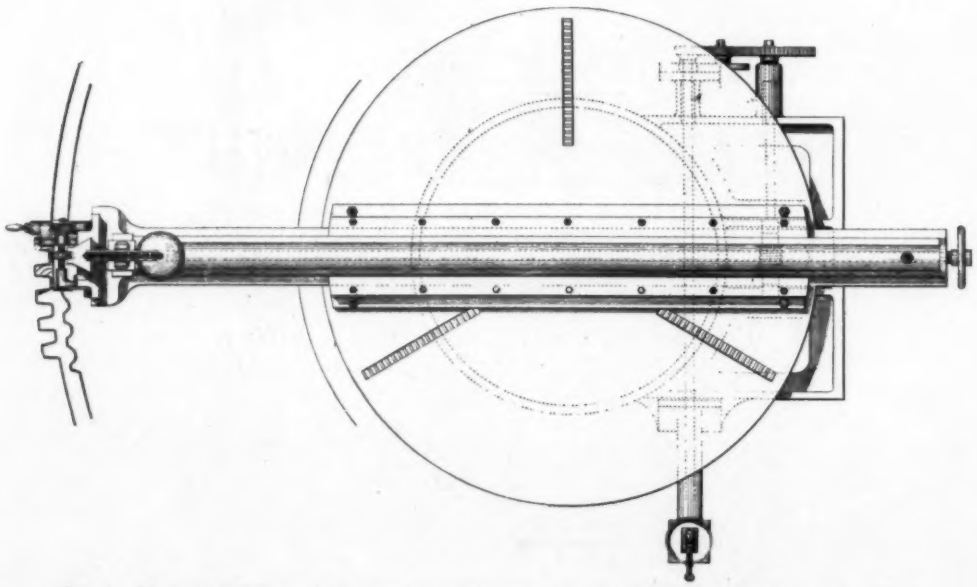


FIG. 4.—MESSRS. BUCKLEY & TAYLOR'S APPARATUS AS A FLOOR MOULDING MACHINE: PLAN.

It is made to swivel around a vertical axis and is clamped. Another feature is the horizontal withdrawal by a movement of a slide on the horizontal arm. This is a necessary fitting, because of the radial fitting of the machine. In the smaller Whittaker machine the socket is an essential part of the moulding table; but in the larger size it is carried on an extension bed, along which it can be slid and adjusted, the change gears travelling with it. For wheels of over 8 to 10 ft., the base and the table go in the floor, and the horizontal arm is removed from the top of the pillar and bolted to the table. In this way provision is made for wheels from 12 to 14 ft. in diameter. For wheels over these sizes the arm is bolted by its flange to a flange on an extension slide, which is bolted to the table. The change wheels are disconnected and reconnected as required. In reference to the methods of withdrawing blocks, these include vertical, horizontal, diagonal, or angular lifts. By far the largest numbers are lifted vertically. All spur blocks are lifted thus, so are those for racks. All bevel wheels can be lifted similarly, but those for helical spurs and bevels, and for worm and screw or angle wheels, cannot be withdrawn bodily upwards. They can be, and are, drawn horizontally bodily.

In Fig. 5 is depicted one of the machines manufactured by Messrs. Wm. Whittaker & Sons,

Limited. It embodies all the essentials of their design for table moulding, but it further has the diameter and of any pitch and width up to 18 in. Fig. 6 shows the Whittaker machine being used on

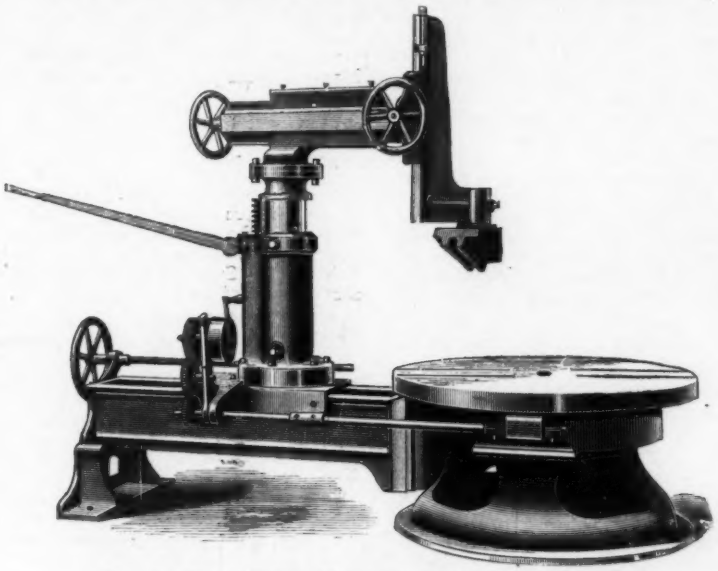


FIG. 5.—GEAR WHEEL MOULDING MACHINE; BY MESSRS. WILLIAM WHITTAKER & SONS, LIMITED.

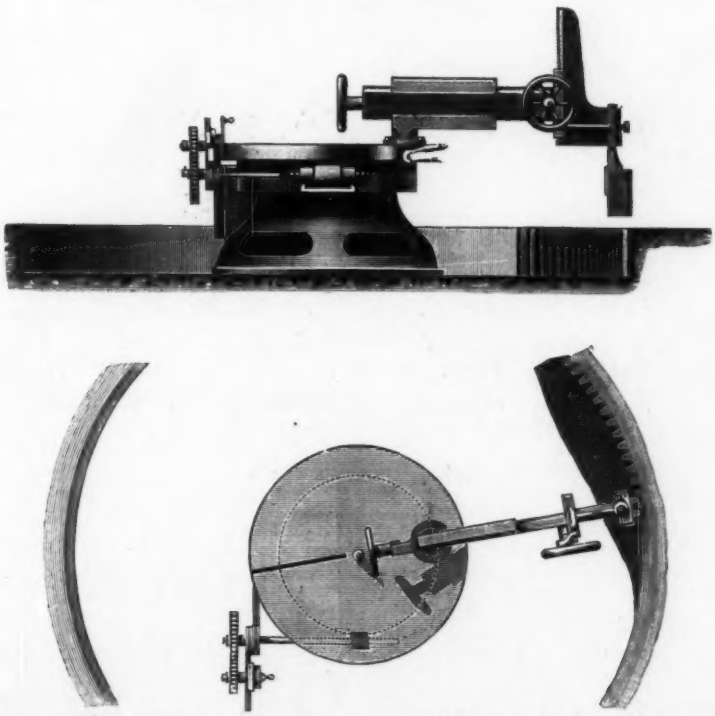


FIG. 6.—THE WHITTAKER APPARATUS BEING USED ON THE FLOOR FOR WHEELS FROM 8 FT. TO 12 FT. DIAMETER.

pillar carried on an extension slide, allowing wheels to be made on the table from 3 ft. up to 9 ft. in the floor and moulding wheels from 8 ft. to 12 ft. in diameter. This is arranged by fixing the head

of the machine on the table and removing the back slide. Fig. 7 shows the Whittaker machine making wheels on the floor up to 30 ft. in diameter, by means of an extension beam bolted across the table, and on which is fixed the head carrying the tooth block. The firm also manufacture a special double helical apparatus for use in making both bevel and spur gears. The bevel or spur block is attached to a down slide with a spigot end, though when moulding spur wheels it is not necessary to change the down slide. The apparatus will draw horizontally 6 in., and is very convenient for drawing straight teeth when these are very wide.

In Scott's machine, the whole horizontal arm has to be moved. In the table and jib machines the whole jib has to be moved. There are stops used for resetting the block to the correct radius, but the method is not satisfactory, being wasteful of time and labour, and liable to cause slight errors. Then there is the desirability of a slide for angular withdrawal, useful in the case of helical bevels. Generally, therefore, a convenient compromise is effected by dividing the tooth block itself in such a fashion that a portion is drawn vertically by the machine slide, and a portion or portions are withdrawn subsequently by the hand in a horizontal or diagonal direction, as is convenient. The portion lifted vertically forms no portion of the actual wheels, being a backing or support for the teeth; the portions withdrawn subsequently are the teeth themselves. There are many ways of jointing adopted. In order to avoid the necessity of jointing blocks in this way, which is, however, often convenient for other reasons than that of facilitating withdrawal, Messrs. Buckley & Taylor's special carrier was designed. This permits of the withdrawal of a block, either horizontally, or at any angle. It is bolted to the machine side by a piece which terminates at the bottom in a disc with curved slots, on which the plate with vee'd edges can be set and tightened at any angle. The slide is fitted to this with a setting up strip, and is traversed along it by means of a hand wheels and screws. The carrier is hinged, so that it can be set and tightened in any position.

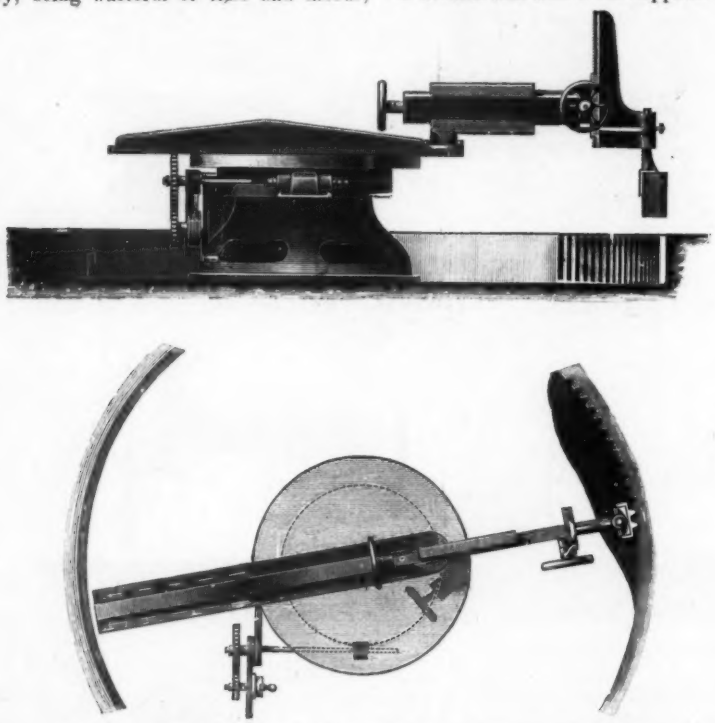


FIG. 7.—THE WHITTAKER MACHINE BEING USED ON THE FLOOR FOR MAKING WHEELS UP TO 30 FT. DIAMETER.

MAKING PHOSPHOR TIN.—For the manufacture of phosphor-tin the following method is recommended in preference to the ordinary method of introducing the phosphorus into the molten tin by means of a phosphoriser. Sponge tin is prepared by melting pure Straits tin and pouring it from a height of several feet into a tub supplied with running water. The sponge tin is then removed and thoroughly dried, or the tin may be prepared in the form of fine shavings. Cakes of yellow cake phosphorus are placed in a saturated solution of copper sulphate for about ten minutes, shortly before they are used, in order to give them a very thin coating of metallic copper so that they may be handled with safety, and they are then dried by rolling in sawdust. The requisite amount of phosphorus (5 per cent. is the usual content for phosphor-tin) is placed in the bottom of a plumbago crucible, covered with the dry, sponge tin, some powdered charcoal added, and the lid of the crucible tightly sealed with a mixture of loam and fireclay. The crucible is heated slowly until the phosphorus has cut the tin and combined with it. The resulting phosphor-tin is then skimmed and poured into suitable moulds, preferably of small size, and set in running water like solder moulds.

Why Crucibles Often Fail.

By Walter J. May.

Complaints are often made about crucibles not giving a sufficient number of heats before they fail, no matter whose make is used. A few years back the writer was informed by a founder that although he had tried a good many makes of crucible, only an average of half a dozen heats could be obtained and, so far as the founder could see, the working could not but be the same as in other foundries.

At that time we were running six fires on six melts per day, on iron, using Morgan's "Salamander" crucibles, and getting an average of twenty-five pourings from each crucible; even then we could have used them for smaller weights of metal, had this suited the work being done. Therefore to use up a pot in six heats with brass appeared rather wasteful, and a visit was paid to the place where this occurred. The cause of failure was patent to anyone who understood crucibles, for the lifting tongs were too small, and crushed in the walls of the crucibles when they were softened by heat. When this was explained the tongs were altered, and no further cause for complaint occurred with the pots. Alterations to the furnaces were also subsequently made, which in other

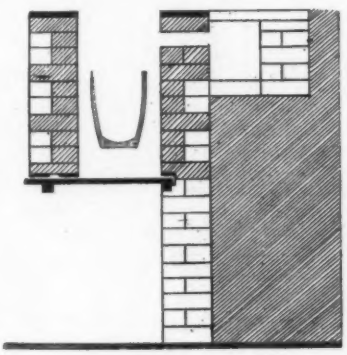


FIG. 1.

ways reduced the cost, while tending to increase the life of the crucibles.

Now, in dealing with the ordinary brass furnaces, good construction is necessary in the furnace itself, and the flue must be above the level of the crucible. This is shown approximately in Fig. 1, and given proper dimensions in accordance with the crucibles used and a good draft, anything up to steel can be melted. However, good furnace builders are scarce, and it often happens that it would be cheaper in the long run to instal some patent furnaces, such as Carr's, which only need the pit to be made for their reception and, of course, the necessary flues and chimney. It would perhaps be as well to mention that the furnace tops should be level with the floor, as this gives the greatest safety; furnaces having the tops higher than the floor are dangerous if the crucible bursts or slips out of the tongs from any cause; for these things do occur at times without any very apparent reason.

Clay crucibles, of course, do not stand many heats, and usually when cooled they split and are done for, but this is not the case with those into the composition of which plumbago enters largely. On the other hand, coke holding a high sulphur content—gas coke for instance—burns the plumbago pots away very quickly, while really the duty it effects can be done more reasonably by using proper foundry coke in the furnaces. The price of a ton of gas coke is only about half that of a ton of good furnace coke, but under ordinary conditions it only does about half the work, and in some cases it does less, the hardness of

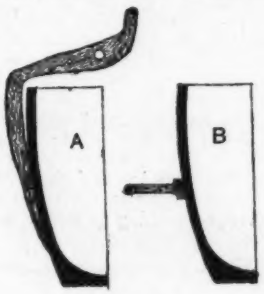


FIG. 2.

FIG. 3.

each particular make varying. But the effect of the sulphur on the crucibles is the worst point, as this reduces their life too much to make slight differences in fuel costs effective, even if such did really occur.

A practice which often prevails is to leave metal in the crucibles to cool; but this, in some instances, causes them to break, and in others it causes holes to burn through, this being dependent on the content of the metal melted. Crucibles should always have

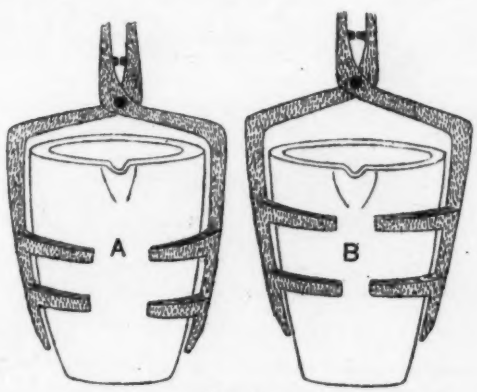


FIG. 4.

the whole of the metal poured out of them before cooling down, and they should be stood mouth downwards to cool. Preferably, any slag should be cleaned out while the pots are hot, but this is not always done, especially where brass is concerned, it often being thought that the matter is of little moment. This, however, really has an effect on the life of the pots.

Of course, all crucibles should be kept in a dry,

warm place, and should be warm when fired, but this should be too well known to require special mention. At the same time the precautions mentioned are not always observed, and in such cases it is not unusual for the crucibles to fail, and this without reference to material or make.

One particularly important feature in dealing with crucibles is the fitting of the tongs and other lifting tools, and to this matter a little attention can be profitably paid. It is unnecessary to here describe the tongs and "bails," or rings, used for pouring crucibles, but there is reason why their fitting should be described. In the first place some particular make of crucible should be used, the tongs and other appliances being made to fit this make of crucible. Tongs may have either one or two rings according to the weight of the pots, and these rings should close together, but they must also be made at such an angle as will enable them to fit the pots, as shown in Fig. 2. In addition, stops should be put into the veins to prevent the application of a crushing force, the object being to have a lifting apparatus which will not crush the pots. As a matter of fact the crucibles should drop into the rings instead of the rings gripping by main force, while the rings of the tongs should close, as shown in Fig. 3, to afford support all round the pot.

In making tongs it must be borne in mind that pots wear away in use, and to get over the difference in size caused by this, the tongs should grip new crucibles at a rather low point, or otherwise when the latter are worn they will slip through. This is depicted in Fig. 4, A showing the postion of the tongs on a new, and B their positions on an old pot.

For handling the crucibles in the fire, a light pair of tongs with a single ring should be at hand, or failing this a pair of bowed coke tongs, as these do not break the edges away like those made in the form of blacksmith's tongs, and even the bowed tongs should only be sparingly used.

Taken in a general way, and having due care used in regard to fuel and handling, the average life of any good plumbago crucible should be approximately twenty melts of iron and thirty of brass or gunmetal, less refractory metals giving a greater number of melts. We should expect to get more than this with some pots, but allowance must be made for differences in fuels and handling. On the averages given, however, the cost per 100 lbs. of metal poured is not at all excessive.

Where chemicals are used with the metals, the life of the crucibles will, in some cases, be lessened, and then it becomes a question as to whether it would not be more profitable to use the short-lived clay crucibles, as with these half a dozen melts per day may be counted a fair duty, although, as a rule, they break as soon as they cool down.

With any crucible, however, its life very largely depends on its treatment, and being rather costly articles care should be taken with them.

Casting Chains.

Various methods of producing chains by casting processes have from time to time been put forward as offering practical solutions to the problem, but on account of the many difficulties involved, and the competition of wrought-iron and steel chains, casting has not been adopted to any extent. The evolution of machinery, which produces from the solid bar chains which are composed of weldless links, has further placed the economical production of cast chains still further off. But, nevertheless, there are times when some method of successfully casting a chain would be useful, particularly in cases where bronze or other alloys are specified.

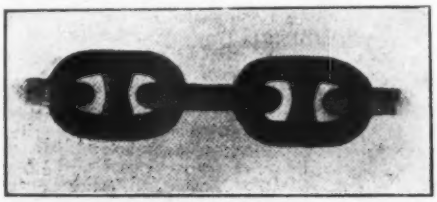


FIG. 1.—FINISHED CHAIN.

Among the methods which have from time to time been put into practice may be mentioned those necessitating the use of a resin or similar pattern. In moulding from such a pattern the links have to be carefully separated and the sand rammed between them; each link, also, must be provided with a runner. These serve the purpose of channels for the escape of the pattern material which, on the mould being heated, becomes fluid, and is poured out. Such a method is described in detail herewith.

The pattern is first carefully bedded in the moulding material and the latter is then heated. The pattern, becoming fluid is poured out, leaving the mould ready to receive the metal. The procedure is illustrated in Fig. 2. The reservoir A contains sand which flows out through the valve controlled opening B. The sand falls into the funnel-shaped pipe D, from which it is forced by an air blast from the blower K into all parts of the mould H, so that the pattern J is completely covered. Before this takes place sufficient sand has been placed in the mould for the pattern to rest upon. At the bottom of the reservoir is a sieve, which is vibrated by the toothed wheel F. By this method it is possible to pack the pattern rapidly and effectively. The method of moulding a chain is shown in Fig. 3. In this each link is provided with a header, and both link and header are made of fusible material. This process has been successfully operated in the casting of steel articles.

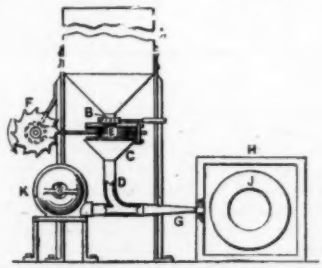


FIG. 2.—METHOD OF MOULDING.

Other similar methods involving the use of such a pattern have been employed, but amongst the disadvantages must be reckoned the destruction of the

pattern, and the trimming involved in cutting off the gate from each link.

Another method, which is distinct from the one just explained, is as follows:—A pattern-plate, as in Fig. 4, is employed, the interior of every other link being formed by a core, shown as core prints in the

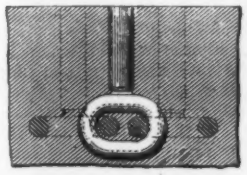


FIG. 3.—MOULDING CHAIN.

CHAIN AS IT COMES FROM THE MOULD.

illustration. A central runner and gates to each link also form part of the pattern-plate. A very fluid steel is obtained and cast into the mould.

A writer in the "American Machinist" gives the following description of the method he employs to cast a chain:—First is made a pattern of one of the links, as shown in Fig. 6. This is made by simply turning a half ring

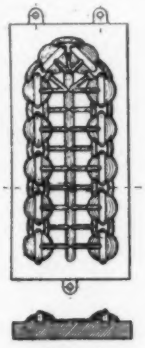
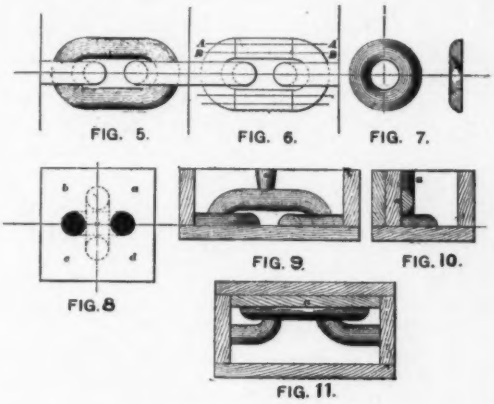


FIG. 4.

on the face-plate, as shown in Fig. 7, which cut in two will form one end of the link, and do the same for the other end, while the intervening straight parts are turned in halves between centres. The joints are put together with glue on paper. When dry the paper strengthens the joints so that one or two saw cuts can be run, as shown in Fig. 6 at *a a* and *b b*, to a suitable depth, into which thin strips may be fitted and glued, thus making a cheap strong joint. The links cast from this pattern are, of course, separate from each other. These are used for every other link in the chain by placing them in a core which makes the connecting link as follows:—Fig. 8 shows an end view of the core when put together. Since each quarter, as shown in *a*, *b*, *c*, and *d* are exactly similar to each other, only one core box will be required to make the four cores to form a complete link. Fig. 9 is a core-box in elevation with the front side off, showing the half round link as it is fixed to the bottom of the box as well as on the side, while Fig. 10 is a section through the centre, and Fig. 11 is a plan of the same. At *a*, in Figs. 10 and 11, is shown a loose side piece on which the link form is fastened, so that when the core is made and drawn out of the box the side form leaves with the core and is drawn out of the side without damage. This is essential, as there is only about $\frac{1}{8}$ in. of sand at one point between the links. The link form inside the box is made up of turned pieces like Fig. 7, but the links which runs outside the ends of the core should be made a little larger to allow the link casting to set in the space. By pasting the two cores *a* and *b* together, and also *c* and *d*, a complete link in two halves is formed. The half core *c d* is now bedded to



the number of links it is desired to cast at one time, and then the cast links connecting the cores together are placed in. The top core *a b* may now be put on, taking care that it matches on its sides perfectly. In the core-box at *a* for the top half is formed a running gate for each link. Where the link joins at *o*, Fig. 8, it would be better to slightly enlarge it, where possible, as it can easily be dressed off the casting on an emery wheel and so insure greater strength, as with the greatest care slight imperfections may occur. The core-box might be lengthened to contain any number of links in one box, and also made that instead of setting in every other space a cast link, all might be cast at one time. In that case it would be more work for the pattern-maker and less for the moulder. If there were any defective castings they could be replaced by the single core described. An elliptical or flattened link could be made if greater strength was required.

THE affairs of Thomson, Son & Company, Limited, Douglas Foundry, Dundee, have been wound up, the preference shareholders being paid in full, and the ordinary shareholders receiving between £5 and £6 per £10 share.

MESSRS. ANDREW BROWN & COMPANY, of 110, Cannon Street, London, E.C., have been appointed agents for the Rotherham Forge and Rolling Mills Company, Limited, Rotherham, makers of steel forgings of all kinds, plain or machined. The Company already represent Penman & Company, Limited, Glasgow, makers of Lancashire and Cornish boilers; Jas. Carrick & Sons, Limited, Edinburgh, makers of electric, steam, and hand cranes; Urquhart, Lindsay & Company, Limited, Dundee, makers of machine moulded wheels, machine-cut gearing, etc.; Saml. Denison & Son, Limited, Leeds, makers of the "Blake-Denison" continuous weigher and semi-automatic weighers.

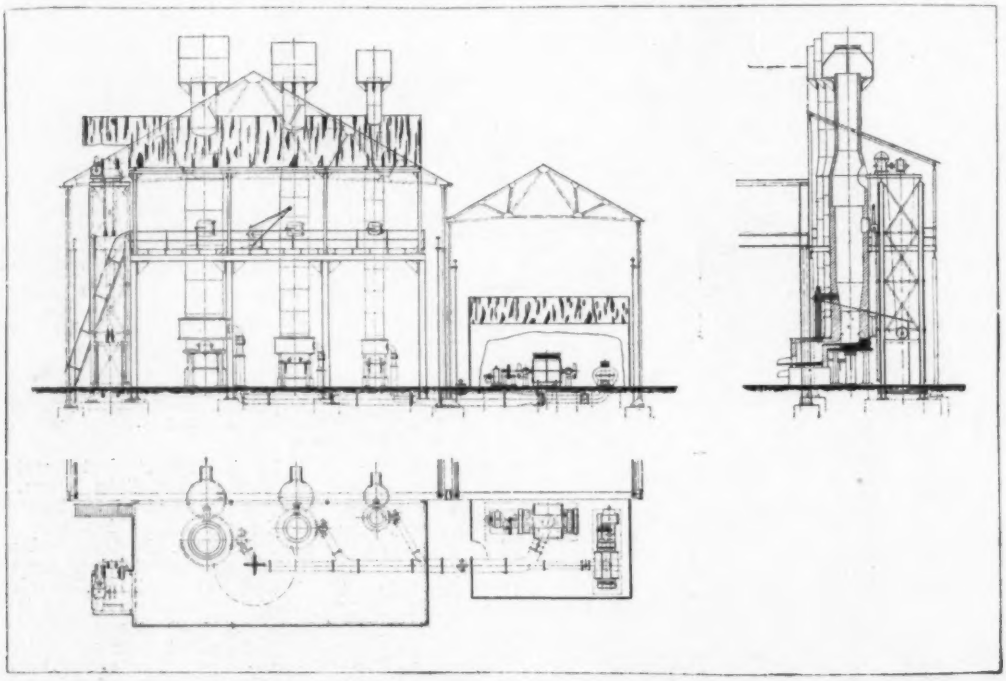
A New Iron Foundry.

We present and illustrate herewith a description of a typical large iron foundry which has been recently equipped throughout by Messrs. Thwaites Bros., Limited, of Bradford, not only with the actual melting plant, consisting of cupolas, blowers, hoist, staging, etc., but also with practically the whole of the auxiliary gear and plant dealing with sand mixing and preparation.

The foundry in question consists of two bays, one having a width of 60 ft. and the other a width of 30 ft., both being 135 ft. long. The larger bay is fitted with a 30-ton overhead crane of the three-motor type, and the smaller with a 10-ton crane of similar type.

The hoist works at a speed of 60 ft. per minute, and is fitted with a 10 b.h.p. motor, and can be actuated from the floor or staging level and from the cage itself. This hoist is constantly dealing with from upwards of 100 tons of materials per day. The load being over-balanced allows a smaller motor to be fitted as it performs work both in hoisting and lowering.

The cupolas are served by two blowers, one of the firm's No. 7 size and the other of their No. 5 size, both being driven direct through reducing gear by shunt-wound electric motors of 60 and 35 b.h.p. respectively. Both of these motors are of the variable speed type, and can be run at any speed from half



A New Foundry, Equipped by Messrs. Thwaites Brothers, Limited.

The three cupolas installed are of the firm's Nos. 10, 6 and 3 sizes, having shells 6 ft., 4 ft. 6 in., and 3 ft. outside diameters, and capable of melting up to 10, 6 and 3 tons per hour respectively. The cupolas are of their standard "Rapid" type, and are in each case fitted with receivers and drop-bottoms. These cupolas are surrounded by a substantial platform carried by steel stanchions at a height of 22 ft. from the ground level. This platform is of liberal dimensions, allowing of a large weight of coke and iron being stored upon it, and is fitted with a small 5-cwt. hand-crane for handling specially heavy pieces on the staging, such as large rising heads, etc., which may have to be remelted.

The materials are elevated by means of a 2-ton electrically actuated hoist fitted with Messrs. Thwaites Bros.' special form of controller, and both electrical and mechanical brakes, which come into action automatically when the cage reaches the top or bottom.

to full speed without loss of efficiency, the regulation in speed being effected by rheostats inserted in the field circuits. This arrangement is an especially convenient one, enabling the blowers to be run at speeds in accordance with the number of cupolas in blast upon any given day; for example, the No. 7 size blower (capacity 11,000 cubic feet per minute), can be run so as to serve without loss of power the 10-ton cupola only, the 10-ton and 6-ton cupolas together, the 10-ton and 3-ton cupolas, or the 6-ton and 3-ton cupolas, whilst the smaller No. 5 size blower can be economically used at half-speed for the 3-ton cupola or at a higher speed for the 6-ton cupola. The larger blower is of the firm's specially heavy "B" series, as at times higher air pressures than are customary are required for the larger cupolas. The No. 5 size blower is of their ordinary type. In view of this fact, an especially large motor is fitted to the No. "7 B" blower, but the usual air pressure

is from 21 in. to 24 in. of water in the air belts of the cupolas. The available current is 440 volts direct current. The coke consumption of these cupolas is stated to be remarkably economical, having reached as low an inclusive figure as 1½ cwts. per ton of iron charged under the most favourable circumstances, but this result was, of course, one obtained when measured over a blow of three hours, and with the best quality of coke. (In this connection it may be of interest to note that Messrs. Thwaites Bros. now have in hand the preparation of drawings to enable one of the largest firms of locomotive builders in the United States of America to alter their existing cupolas, of an American make, to their standard arrangements.)

They have also supplied the foundry illustrated herewith with ladles of various sizes having capacities of from 25 tons to small hand-shanks to hold ½ cwt., sand sifting and mixing apparatus, loam mills, rumbling boxes and dressing wheels, all the latter being driven by electric motors of a type specially constructed to obtain the maximum amount of protection from sand and dust without unduly affecting the ventilation of the armatures. It will be noted in the illustration that the cupolas are fitted with the firm's drum type spark arresters.

Körting Pneumatic Nozzle for Cleaning, Damping, and Blacking Foundry Moulds.

The ordinary method of cleaning up sand moulds by means of a bellows or a jet of compressed air is attended with the inconvenience that, with the bellows, there is considerable risk of damaging the moulds, whilst in the other case the amount of air consumed is considerable. In the pneumatic nozzle, introduced by Körting Brothers, a jet of compressed air is employed to create a strong current of atmospheric air that is drawn in through the nozzle, so that a much larger stream is produced than when the compressed air is used alone.

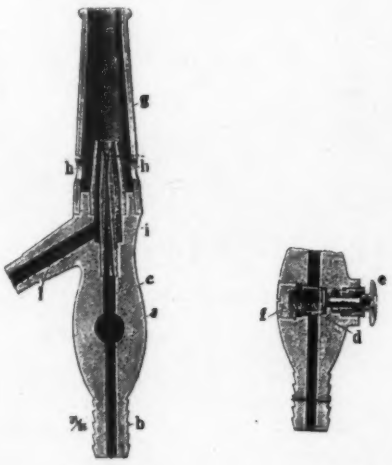


FIG. 1.

FIG. 2.

KÖRTING PNEUMATIC NOZZLE.

The device, which is shown as a cross section in Fig. 1, consists of three concentric nozzles; an inner one, *i*, for the compressed air, an intermediate nozzle, *k*, for the damping liquid, and the outer cylinder, *g*, into which air is drawn through the holes, *h*, *h*. Connection is established with the water tank by means of a flexible pipe, attached to the branch, *l*, projecting from the handle. By means of this device the moulds can be cleaned out with a comparatively small amount of compressed air, a very powerful and controllable blast being obtained. The nozzle is put in communication with the source of compressed air by means of a flexible pipe attached to the handle at *b*, and the supply is regulated by a small valve, *d* (Fig. 2), arranged in the airpipe and operated by a press button, *e*.

The apparatus is very easily handled. When the cleaning up of moulds is in question, the pipe leading to the liquid tank is detached, and the button, *e*, is pressed with a force varying with the strength of blast desired, to open the valve against the pressure of the closing spring, *f*. When the moulds are to be damped, the pipe from the tank is attached, and the valve operated as before, the force of the escaping air drawing in the liquid and converting it into fine spray. Fig. 3 shows the apparatus at work.

FIG. 3.—KÖRTING PNEUMATIC NOZZLE AT WORK.

Further Progress in Moulding Machines.

An interesting example of the rapid development in moulding machines that has taken place within the last few years is illustrated in the two accompanying photographs. Fig. 1 shows a large hydraulic moulding machine for making the tunnel plates used in the Paris Underground Railway, whilst in Fig. 2 is seen a number of the plates fitted together for testing their accuracy, on the casting floor.

This moulding machine has been expressly designed and constructed by the London Emery Works Company, Park, Tottenham, London, N., for this particular work, and takes moulding boxes up to 6 ft. 6 in. by 3 ft. 3 in. It is of the turn-over pattern plate type, and is arranged for hydraulic power to do both the ramming of the moulds and the extraction of the pattern. After ramming the mould, the plate, with moulding boxes attached, is turned over and the moulding box rests firmly on a cast-iron trolley mounted on four wheels on rails, on the floor level, whilst the pattern is being drawn; this is then pulled out and the box removed by an overload travelling crane.

Another special feature in connection with the machine as an aid to increase the output, is the sand bin placed on the top of it; sand is delivered to this bin automatically, and the moulding box is filled by withdrawing a slide in the bottom. The saving of time in filling the moulding boxes of this size is up to 50 per cent. The output is very large, and in the foundry where the machine is at work a considerable advance has been made as compared with hand moulding.

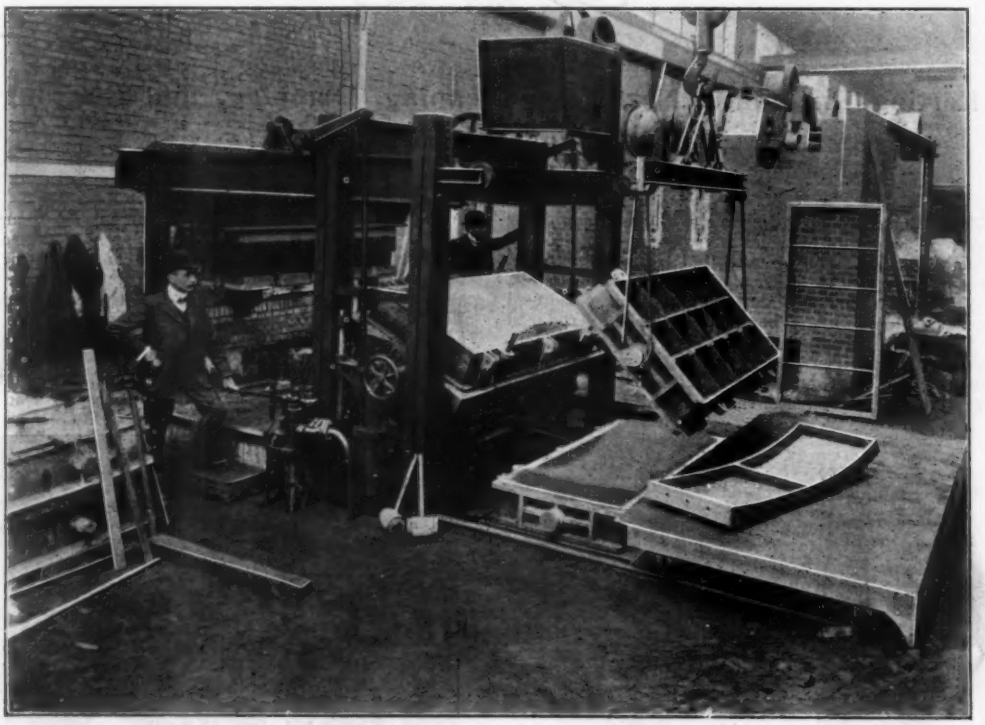


FIG. 1.—HYDRAULIC MOULDING MACHINE FOR TUNNEL PLATES.

A LARGE number of foundrymen met under the auspices of the Sheffield and District Branch of the British Foundrymen's Association on March 27 to hear a lecture by Mr. F. J. Cook, of Birmingham, president of the parent Association, whose subject was "The Physical Testing of Cast Iron." The meeting was held in the Applied Science Department of the University, and Mr. Percy Longmuir presided.

OWING to the growth of the metal department hitherto conducted by the Filale der Zivnostenská Banka pro Cechy a Moravu in Budweis, it has been decided to transfer the control to the Company's head office at Prague, and in future the business in London will be carried on under the style of the Zivnostenská Banka, London Agency, St. Benèt Chambers, Fenchurch Street, London, E.C.

Notes on the Prevention of Defects in Castings.

By F. Hall.

In even the best managed foundries there will always be a certain percentage of defective work, but as the exercise of a little care will often materially reduce the scrap heap, the following notes may suggest, particularly to young moulders, some ways of avoiding spoilt work and reducing the defective output. It is necessary for all connected with the foundry to give every possible attention and study to small items, for these, if neglected, count for much loss of time and material.

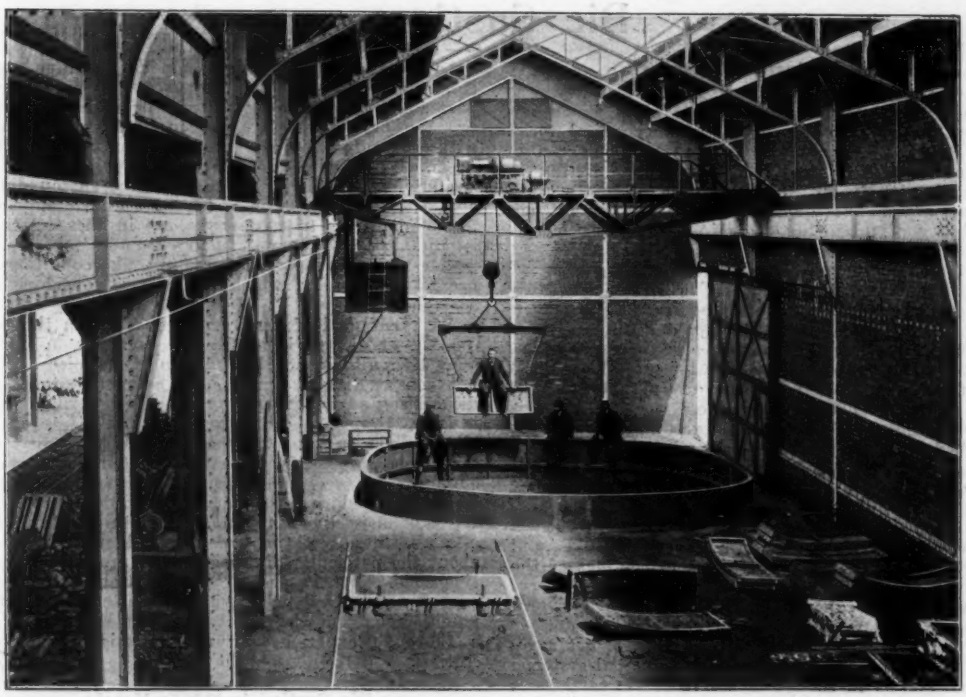


FIG. 2.—TUNNEL PLATES MADE ON THE HYDRAULIC MOULDING MACHINE.

Machined castings stand first for consideration, because the costs of machining defective castings is a serious item. Most pattern-makers mark with a special colour those parts of pattern where machining will be required, as a guide to the moulders to take precautions with those parts. Tough, ground facing sand should not be used on these parts of pattern, as this will prevent the free escape of gases and air. The vent wire should be used freely on this class of work, both above and below the patterns. The gases and air are the moulder's most troublesome enemies, so that great care must be used to get these quickly away when pouring the molten iron. Much iron is used before the sulphur fumes or gases have escaped from it in the ladle; if this is done with machined castings many defects will be found, generally on back or top parts of the castings. These sulphur holes are known by the silvery interior. When pouring a mould, keep the runner full of iron, or air will enter the mould in such force to displace a part or parts. Be careful in mixing the facing sand that sufficient coal dust is in it to resist the iron, or seams and scabs may result; pouring the iron at too great a heat often has the same effect. Many defective castings are produced owing to the excess of water used on green sand moulds. Further, it chills the castings and runs up costs in the machine shops. Give special attention to skimming the iron carefully before pouring, as neglect here spoils many otherwise good castings. Cover very quickly all moulds with large surfaces, and place the runners so as to give the easiest flow of iron through the mould. Roughness is often caused by too damp facing sand, or insufficient coal dust or charcoal on the face of mould, or pouring iron at too great a heat. Roughness, however, is not so material where machining follows.

Small machined work made on the moulding machines as repetition work requires open sand, as this class of work is rammed hard by extra pressure, and there is danger of small blow-holes being found. The runners should always be cut in proportion to the size of the pattern, so as to ensure them being kept full of iron when casting. Sleeking with the trowel the parts to be machined must be avoided, as this produces a glazed surface, and is most likely to produce blow or air holes. Sleeking with the trowel the top parts of the moulds is a frequent cause of castings being found defective when machined, as the gases are thus partly prevented from escaping freely.

The iron mixer fulfils a very important duty, and often defective castings are produced that cannot be traced to the moulders. I refer to the burnt iron sometimes getting among the better class of scrap iron. The soft brands of iron give most trouble to

moulders, as the shrinkage is great, and this metal does not travel so freely in the mould, or so easily throw off its dross in the ladle. This must be borne in mind for certain castings, or trouble will result.

Among the items which no moulder can afford to neglect are the questions of the heat of the iron, the hardness of top parts in green sand moulds, skimming, venting, proper size and position of runners, the avoiding of seams, scab and roughness, the strength and weakness of facing sands, and the making, drying, and fixing of cores. Great care, too, is required when placing wood patterns on the sand odd sides, so that they are firmly placed for ramming up. Neglect here often produces defective castings. The mending up of what is termed a bad lift must be given considerable care, in order to ensure that no crush results or sand becomes displaced in the mould. Facing sands present an important problem, for with a variety of castings to be made, no hard and fast rule can be laid down except that the sand must be used as open as possible on machined parts, and only slightly moist on castings wanting a clean smooth face. The great question is, will the castings that look so good in the dressing shed, stand the tests of the machine shops; if so, they reflect credit on the moulders and all concerned.

Die Castings.

Castings in Brass.

Die castings or pressure castings, also known as finished castings, have taken their place as an important factor in the commercial and mechanical world. Mr. H. H. Doehler, President of the Doehler Die-Casting Company, Brooklyn, New York, writing in "The Metal Industry," states that heretofore a great limitation was put upon them by the apparent impossibility of producing them in high fusing metals such as brass and bronze.

"All concerns engaged in producing die castings," he continues, "are using white metal alloys. Most of these are zinc alloys containing from 80 to 90 per cent. zinc alloyed with tin, copper and aluminium in various proportions. There are also some tin alloys used, but the comparatively high price of these alloys and their softness reduce their useful field to very narrow limits. The best and most used tin alloy is Parsons' white brass and its largest field is die-cast 'finished bearings.' Some lead alloys are also used successfully, and I believe our concern has been the first one to introduce a steam-resisting lead alloy cast in metallic moulds for finished parts.

"Recognising the enormous field and output if a yellow metal could be successfully cast in moulds, and also realising the limitations and shortcomings of the white metal die castings, I started a number of years ago a series of experiments to perfect such a process. As in all radical changes, important inventions and fundamental improvements, one has to get away from the established grooves and antiquated systems. The old system in the manufacture of die castings is a plunger casting machine. This casting machine has a cylinder submerged in the molten metal and a plunger working in and out and over an opening forcing the fluid metal by lever power into the mould. By perfecting a new process with new principles, success in casting brass in metallic moulds was attained.*

"Finished brass castings, as the name indicates, are cast in a finished state requiring no further machining. The castings come from the mould with all holes, lugs and other irregularities cast, and all dimensions accurate without being machined. By our way, the manufacturer sends in a drawing or model from which we construct a metallic mould, good for any number of castings. Our castings are delivered in a finished state, ready for assembling, thereby doing away with machinery.

"However, I do not wish to convey the idea that we can cast by our process any and all kinds of brass parts. Being aware that our process is in its very infancy we have so far attempted only small castings, not over 8 ozs. in weight. This does not mean we are limited to this weight; on the contrary, there is hardly a weight limit in our process. Very intricate parts, or such requiring a great deal of machining, are the best adopted. We cannot as yet compete with the automatic screw machine or the stamping press. I also wish to state at this point that it is absolutely essential for us to know the surroundings, application and function of the part we are supposed to make. While the brass we use in these castings is suitable for any part made from cast brass, we prefer to know, for various reasons, the conditions it has to work under, which we have to consider each case individually.

"A great deal of harm has been done in the production of die castings of white metal by using an alloy not suitable for the function of the piece, or by not constructing the part in a manner suitable for die casting so to give strength by design where it is lacking, owing to the nature of the white metal alloy. Even in brass the makers need the fullest details to be able to give satisfaction. Close dimensions ought to be especially indicated. It is beyond human efforts to produce, at a commercial rate, parts with 10, 20 or more dimensions accurate within thousandths of an inch, but if the makers are kept uninformed about the particular dimensions they are apt to waste time and effort in the wrong direction. Such accuracy naturally depends on the construction of the mould, requiring the finest workmanship backed by a thorough experience in mould designing for die casting.

* The abstract of the specification of a patent recently granted in England to Mr. H. H. Doehler was published in our April number, the apparatus patented being apparently that referred to in this article.

Die Casting in White Metals.

In the same journal Mr. A. Trowbridge, of the Veeder Manufacturing Company, Hartford, Conn., U.S.A., discussing the making of castings in metal dies, remarks that many improvements have been made in the art in the past few years. No better proof of this, he says, is required than an examination of one of the cyclometers or counters made by this process at the works of the Veeder Manufacturing Company, in Hartford, Conn. These instruments consist of a number of small rings, together with their actuating mechanism and gearing, contained in a suitable case.

Mr. Trowbridge continues:—"The basis of 'Veeder' metal is tin. This makes the castings lighter than brass pieces of the same size. It also makes a white metal which is uniform in colour throughout, and does not tarnish on exposure to the air or to moisture. This non-tarnishing quality makes it possible to use these castings without plating them, and should they become worn from contact with the fingers or with other parts, no change of colours is noticed. The metal can be plated, if desired, and a surface obtained to match the colour of any other metal. Die-moulded castings are smaller than the

sizes of the dies in which they are made, because the metal shrinks somewhat in cooling. This shrinkage varies with the shape and size of the piece. It can be calculated quite closely for simple pieces, but when it is necessary to match parts made in any other way, it is advisable that the die castings be made first and the other parts fitted to them. If this is not done, the dies in some cases must be so made that they can be ground down to size after a number of sample castings have been made to determine just what the shrinkage will be.

"The exact strength of the metals which can be cast in steel dies is of vital importance in determining their usefulness. The tensile strength of 'Veeder' metal is about equal to that of cast iron, being 15,000 lbs. per square inch. Its compressive strength is about 20,000 lbs. per square inch, hence it is not adapted for use under heavy pressures. It is much more ductile than cast iron, and can, as a consequence, be used for very thin pieces. Moreover, its toughness permits of its being tapped even though the walls are very thin. It is apparent that to secure uniformity of castings, the treatment of the metal in this work must be uniform. On account of this no variation of hardness can be obtained except by varying the alloy. The amount of this variation is quite limited with any one metal, so that proper allowances must be made in the design of die-moulded parts to secure the necessary strength and rigidity. Some variation can be made in the composition of the metals used for die casting and various degrees of hardness and strength obtained thereby. The Veeder Company have three grades of metal. The most commonly used is their softest mixture, called No. 1 metal, which can be readily spun or riveted. The medium hard metal can be spun slightly and is stronger and wears better than the No. 1 metal. The hardest metal is used mostly for pieces that must withstand compression. This grade is too brittle for spinning.

"In buying die-moulded castings, one pays for no waste metal. As the pieces are finished when they come from the dies, there are no chips to be saved and stored. The usual manner of calculating the cost for these castings is to charge a certain amount for making each casting, and add to this the cost of the metal. Only the metal in the finished pieces is charged for, because any scrap made in getting out these pieces can be melted again at slight cost."

The Development of the Iron and Steel Industry in India.

By an Indian Correspondent.

To those connected with the iron and steel and foundry trades in the United Kingdom it is of interest to note the steady advance that is being made in the British Dependency of India, affecting, as it does, the trade of the Mother Country and providing a gradually widening field for British labour and at the same time an avenue for British capital. Until quite recently the general impression amongst Englishmen was that India, mine of mineral wealth though she be, was almost destitute of iron, coal, and the general wherewithal to produce pig-iron for steel-making and general foundry work. Some there were who knew better, for Mr. Theodore Hughes, a mining engineer, after a visit to India nearly 40 years ago, spoke very highly of the iron ore deposits of certain parts of the country.

Even to-day India is not considered at all as an iron-producing country, as can be seen at once by a glance at the statistics of the world's production of that commodity. As a matter of fact, her total production is only about 35,000 tons annually, of which 70 per cent. is produced at one works, viz., at Barrakar, in Bengal, where a phosphoric foundry pig is produced and supplied to all the principal users of pig-iron of this kind in India. This is an excellent pig-iron within its own sphere of utility, and mixes well with British pig-irons of a purer quality.

The quantity of steel produced is said to be nil, but this is by no means correct, though what small quantity is made is entirely absorbed by home users, with the notable exception of the variety known as "Wootz," the manufacture of which is confined to the native, who produces it in small quantities for the most part in his forest home, and despatches it to the coast. Here it is greedily secured by those European manufacturers who have need for a steel possessing the qualities peculiar to "Wootz" steel, which include the ability to take a high polish on a damascened surface, a high temper, great tenacity, and the capability of being drawn down to very thin sections, and taking and retaining fine points and cutting edges. The process of manufacture, crude and ancient though it be, and often described by European writers, as it has been, is by no means well understood as to its essential details.

It is perhaps not generally known that in India there is at least one fairly large open-hearth steel plant with rolling mills attached. Such a plant is owned by the East Indian Railway Company, and is in full and regular work, the process being acid Siemens-Martin. In addition, at least one company is operating successfully a steel plant worked on the Tropenas or side-blown converter principle.

Many fairly large foundry plants are to be found in the chief cities of India, dealing with outputs that compare well with that of the average British iron-foundry, and worked almost entirely with native labour, but with European supervision and appliances, and imported stock. Prominent among these is the foundry of the Vulcan Iron Works, in Calcutta, where castings of good size and quality are regularly turned out.

At least two blast furnaces of about 75 ft. in height will be erected primarily; they will have boshes of 17 ft., and a working daily capacity of about 200 tons each. The steel furnaces will be of the basic open-hearth type of 40 tons' capacity, capable of consuming about 130,000 tons of pig-iron annually, with the production of nearly 120,000 tons of steel.

The Tata family itself is purely Parsee, though the money provided for the concern, as a whole, is by no means all Indian.

Industrially the enterprise provides an example of the true *swadeshi* movement, for this is *swadeshi* pure and simple, as none but native raw materials will be used. The market will be entirely Indian, and the labour—that is actual labour—will be almost exclusively native. This brings us to the last, and probably the most important factor in the success of the concern, viz., the labour question; whether such a plant can be worked with native labour to produce a material equal in quality to European or American, or sufficiently good for Indian consumption. The point is debatable, and one on which people of some experience and authority on the climatic conditions prevailing in India generally, and Bengal in particular, have ventured to express negative opinions.

The Manufacture of Motor Car and Wagon Cylinders.

By J. Peers.

There is no branch in the art of moulding receiving more attention at the present time than the moulding of motor car cylinders. The castings have to stand high tensile tests, and be as thin in section as is possible with safety. The cylinders must on no account be too hard, or they are rejected. The work has to be particularly clean and accurate. The patterns should be made in halves and, if of wood, they should be made from mahogany, and all loose pieces dovetailed into the pattern. The pattern-maker should have ample time allowed when making the patterns and core boxes, for a very small difference in thickness will be disastrous to the finished product. The moulding boxes should be of iron, with holes cast in, half in drag and half in cope at the ends, the amount to be determined according to the number of risers or gates required. This allows of gate and riser pegs being rammed up with the mould, for to be successful this class of work should be cast on end. The lugs for the guide pins are cast on the side of the box, so as to be out of the way when making up the runners and risers.

Sand and Cores.

All new sand should be used, with a little clay wash as a binder, no coal dust being necessary. The sand should be well milled, to make the particles as fine as possible. The reason for this milling is, that when drying the moulds a certain expansion is bound to take place on account of the heating, causing the grains of sand to expand, and when the moulds have cooled down the grains cannot regain their former position. If a coarse sand is used, the expansion is greater, and when the parts are put together the mould will be probably fractured; if not seen when closing the mould, the tightening of clamps or bolts may reveal it.

A good sand for this class of work approximates the following analysis:—

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
83.40	6.26	4.10	0.66	0.50

The moulds should be painted before drying with wet plumbago, a fine camel hair brush being used to prevent any marks showing on the outer surface of the casting. All moulds should be dried and when drying care should be taken not to overheat them, or the surface will easily wash away, and a dirty casting will be the result. About eighteen hours' drying is a fair average allowance.

The cores for the jackets and smaller cores are very intricate, and the best wax wire vents are to be preferred. If this policy is not strictly adhered to, and inferior brands used, the vents will probably clog up, the wax not clearing itself properly and leaving the channel blocked. The supports for these cores are steel wires cut and bent to the contour of the box, and are easily removed. An oil-sand is used at times, but this is not a necessity.

All cores should be tested before leaving the core bench or stores to see that all vents are clear. The author has seen varied ways of testing; a very good one is to smoke a cigarette and blow the smoke through the vent.

The boring up of the moulds is practically a branch of itself, and great patience is required in this part of the manufacture. The first core must be set in position accurately, and if any nails are required to support it, gauges should be used to measure the distance from the bottom of the mould. A common practice to determine the thicknesses is to set the bottom half of jacket core in its position, place a piece of clay or stiff loam on it, about the size of a Barcelona nut; then place the barrel cores in and on the top of these a similar piece of clay or loam; then the top half of jacket core is put in its place. All cores being now in their respective positions, the top half of the jacket core and barrel cores are removed, and if the two pieces of clay correspond in height, the thickness may be regarded as equal throughout. To bring the vents away from the cores, when fixed in their proper positions, a tube is pushed through the drag part of box before the pattern is drawn out, as many holes being made as there are core prints on the pattern. To prevent the metal getting past the ends of cores, a composition of oil and blacking mixed to a paste is plastered on the edges of the cores; this does not prevent the mould bearing well on the core, and it is very effective in preventing the metal escaping, and probably causing a blow up. All loose bits are now blown out from mould and core, the cope tried on and off and finally closed. The parts are now bolted or clamped together, and stopped in with loam at the joints, and the box turned on its end. The box is made to slant down from the riser end to the gate end, double the height being employed in the runner box to that used at riser end. This tends to give a sounder casting, acting as a self-feeder.

Iron Mixture.

The following is the approximate analysis of an iron mixture which is giving satisfactory results:—

GC	CC	Si	S	P	Mn
3.00	0.60	1.7	0.08	0.76	0.55

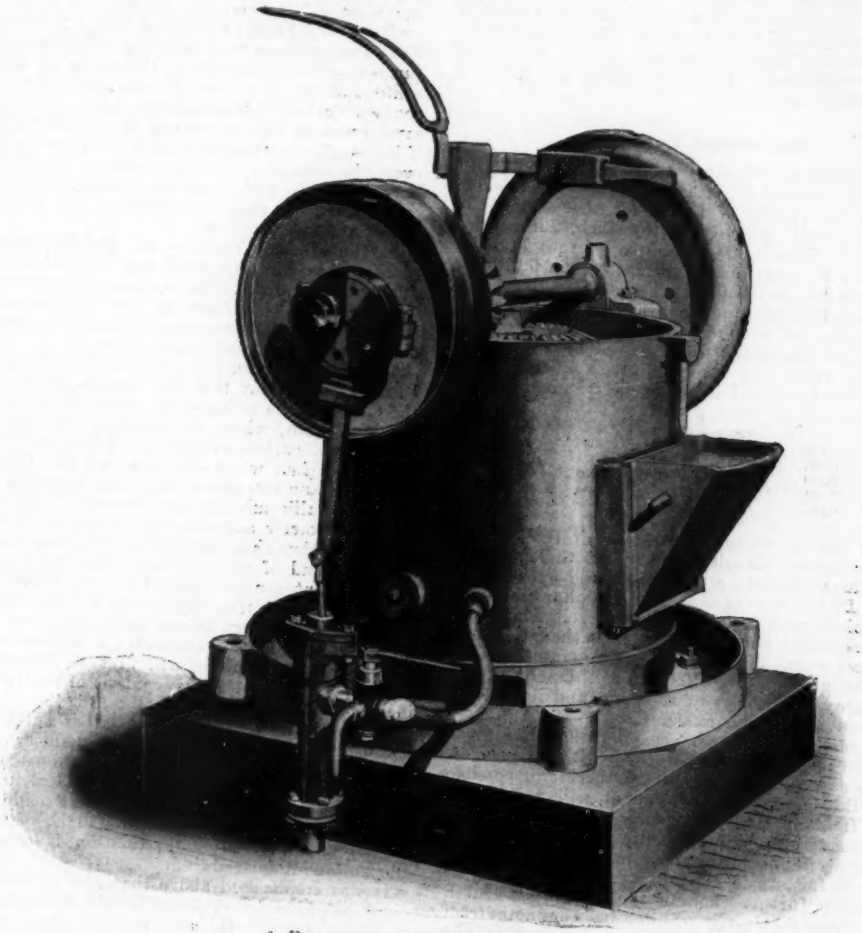
The iron is remelted and castings are run direct from the cupola. Formerly the crucible was used and this is still the practice in some places. To get the best results from the mixture given, the foundry foreman or manager should be able to calculate losses and gains during remelting, the best metal being that which is mixed without the use of alloys in the ladle after melting. Everyone in charge should understand his own cupola, for to some extent each cupola has a peculiarity of its own, and the best can only be got from it by one who has had daily experience with it.

The advantage of shallow beds is often advocated as a means of saving in fuel consumption; the saving in fuel no doubt can be obtained, but it is an erroneous idea if there is no receiver attached. Where a shallow design is in use I would advise a receiver if good quality iron is wanted. The extra cost in the fuel is easily counterbalanced by the better class of castings.

Barlow & Chidlaw, Limited, machine-cut gear makers, etc., of Pendleton, Manchester, have opened a London office at St. Stephen's House, Westminster, London, S.W., under the charge of Mr. H. J. W. Oxlade.

A Brass and Coke Recovery Mill.

The recovery of brass and coke from brass-foundry ashes and slag has come somewhat to the front of late as a means of effecting economy in connection with brass-foundry works. The illustration shows a mill designed for brass founders and refiners for this purpose. It is driven by belt power, and the grinding, stirring, and washing processes are performed simultaneously, about a ton of material being the amount that can be treated per day. The mill, it is claimed, has been proved to be a source of economy. The weight of the apparatus is 26 cwts., and the makers are Messrs. Hardie & Gordon, Levenbank Foundry, Dumbarton, N.B.



A Brass and Coke Recovery Mill.

Seventh International Congress of Applied Chemistry.—The seventh International Congress of Applied Chemistry will open in London on Thursday, May 27, under the patronage of H.M. the King and of H.R.H the Prince of Wales. The Prince of Wales has graciously consented to perform the opening ceremony at the Albert Hall. The Honorary President is Sir Henry Roscoe, and the Acting-President, Sir William Ramsey. Lectures will be delivered to the whole Congress by Sir Boverton Redwood and by Professors Haller, Paterno, and Witt, and meetings of the sections will be held for the reading and discussion of papers. There will be a banquet at the Crystal Palace on May 28, at which an attendance of about 2,000 persons is expected, a reception at the Guildhall on May 26 by the Lord Mayor, and on May 27 a reception at the Foreign Office. Arrangements are also in progress for the entertainment of members during several evenings. The fee for membership has been fixed at £1, and application should be made to the Honorary General Secretary, Mr. W. Macnab, 10, Cromwell Crescent London, S.W., who will furnish any further information.

Removal of Sulphur in Electric Steel Furnaces.

The removal of sulphur in electric furnaces for steel refining has been the subject of two recent independent investigations, of which one has been carried out by Dr. Th. Geilenkirchen in the daily practice with the Héroult furnace in the steel works of the Rich. Lindenberg Company in Remscheid-Hasten, while the other research has been made by Professor Bernhard Osann with a 1,000-kg. Roechling-Rodenhauser modified induction furnace in the Roechling works at Voelklingen. These two papers are given in full in "Stahl und Eisen."

The Heroult Furnace.

The fact that an effective removal of sulphur takes place in the Héroult furnace is proved by Dr. Geilenkirchen by the results of 1,000 successive charges in the ordinary daily practice of the Rich. Lindenberg Company. Of these 1,000 successive charges 74.3 per cent. gave a steel containing not more than 0.010 per cent. of sulphur, while 95.8 per cent. of all charges gave a steel containing not more than 0.015 per cent. These good results were not due to the use of especially pure raw materials, as is proved by the following figures, which give the percentage of sulphur in the liquid steel charged into the electric furnace for refining during the same period:—

0.114	0.133	0.035	0.099	0.055	0.069
0.076	0.204	0.070	0.500	0.075	0 131
0 050	0.100	0.038	0.037	0.070	0.450
0.158	0 064	0.142	0.086	0.045	0.060
0.036	0.123				

To give the metallurgical *rationale* of the removal of sulphur in the Héroult furnace, Dr. Geilenkirchen first compares the latter with the basic open-hearth furnace. In the molten steel bath sulphur is chemically combined with iron and manganese. These sulphides are soluble both in the steel bath and in the slag. The amount of sulphides passing into the slag will be the greater, according to the height of the temperature, the basicity of the slag, and its content of lime and manganese oxide.

These conditions can be easily fulfilled in the Héroult furnace. The temperature of the slag below the arc is exceedingly high. It is, therefore, possible to make the basicity of the slag at will as high as desired. It is especially possible to make the content of lime considerably higher than in any other process. Under these circumstances the removal of sulphur in the Héroult furnace in the way sketched above must proceed much further than in the basic open-hearth furnace. Nevertheless it cannot be complete from this single point of view, because according to the laws of equilibrium sulphides must always remain in the steel bath as long as the latter is in contact with a slag containing sulphides. Of course, by renewing the slag and using a new slag free from sulphur, more sulphur will be removed from the steel bath. But this method takes time and is expensive.

If the sulphur is to be removed completely, it is necessary to bind it quantitatively in form of a sulphide insoluble in the steel bath. The only sulphide which is to be considered is calcium sulphide. But if calcium sulphide is present in the slag, it has a great tendency to oxidise and form the sulphate $CaSO_4$. According to Finkener's experiments this will react with iron without fail according to the equation:—

(1) $CaSO_4 + 4\,Fe = FeS + 3\,FeO + CaO$.

The sulphur then passes back into the steel bath.

The Change of Iron Sulphide into Calcium Sulphide.

With respect to the change of iron sulphide into calcium sulphide, it is known that it requires the presence of a strong reducing agent. For instance, the reaction by which sulphur passes into the slag in the blast furnace is:—

(2) $2\,CaO + 2\,FeS + C_2 = 2\,CaS + Fe_2 + 2\,CO$.

The same reaction may take place in the open-hearth furnace with simultaneous reduction of the carbon content of the slag; it will take place directly at the contact surface between steel bath and slag. The same reaction will also occur in the Héroult furnace if high-carbon and high-sulphur steel is treated. However, the easiest way of operating a Héroult furnace is to feed it with molten decarbonised and over-oxidised iron so that the conditions for the above reaction are not fulfilled.

In the Héroult furnace the desired change takes place within the slag itself and is a result of its reducing nature, due to the presence of calcium carbide. Calcium carbide is used for the deoxidation of the bath and forms spontaneously in the furnace under the action of the electric arc.

The strongly reducing slag first deoxidises the steel bath in such a way that the metallic oxides pass into the slag and are reduced to metal which returns into the steel bath, while the calcium carbide is oxidised to lime and carbon monoxide. After this reaction is completed (*i.e.*, when the slag and the bath contain no longer any metallic oxides), the reducing slag acts on the metallic sulphides and changes them to calcium sulphide exactly according to equation (2) (with the only exception that calcium carbide acts as reducing agent instead of pure carbon). In this way the sulphur content can be reduced to any desired amount, if only sufficient time is allowed for the reaction.

It is not necessary to use pure lime. free from sulphur. If the lime contains sulphur in form of calcium sulphate, iron sulphide will first be formed according to (1) and the sulphur content of the bath will be increased. But this will not affect the final result. The practically complete removal of sulphur by reaction (2) does not depend on the quantity of sulphur present. The only conditions which must be fulfilled are a sufficient amount of lime and calcium carbide and freedom of the slag from metallic oxides; as long as oxides are in the slag, they will be preferably reduced, and only after deoxidation is complete will the sulphides be reduced.

It was emphasised above that any oxidation of calcium sulphide to sulphate would make success impossible. In the Héroult furnace this oxidation is impossible for two reasons, one being the strongly reducing nature of the slag, and the other the fact that the Héroult furnace has a neutral atmosphere, which distinguishes it sharply from the open-hearth with its oxidising atmosphere.

The Process of Desulphurisation.

It is now easy to sketch the process of desulphurisation in the Héroult furnace. If the treatment begins with oxidising smelting, the oxidation is accompanied by desulphurisation in the same way as in the open-hearth furnace, but to a much greater extent, because the slag in the Héroult furnace is of high fluidity and therefore a good solvent. The sulphur passes into the slag in form of sulphides of iron or managnese.

During the following deoxidation period (with which the electric-furnace treatment will begin in general) iron and manganese sulphides will pass into the slag as long as the latter contains oxides. But this will have no effect on the final result. The removal of sulphur during the deoxidation period really begins only when the slag no longer contains metallic oxides. Then calcium sulphide is formed by reaction (2), as described before.

Practical experience confirms these views. In the beginning of the treatment the removal of sulphur is quick, as a result of increasing temperature. Then follows a period during which the sulphur content remains practically constant until the slag gets free from metallic oxides. The slag then disintegrates to a white powder. Beginning from now on, the removal of sulphur is again rapid, until the final results, given above, are reached.

In this process two points are of special importance.

First, desulphurisation in the Héroult process is not a separate operation, but accompanies the deoxidation. In the Héroult process it may, therefore, be said to be impossible to retain any appreciable amount of sulphur in a thoroughly deoxidised charge; and this is true whether the sulphur content of the raw material is high or low.

Secondly, the desulphurisation in the Héroult process goes on without any effect on the chemical composition of the steel bath in other respects. This is of importance for various branches of the steel industry, but especially for foundry practice, if for special castings a low content of manganese or silicon is required. Cast iron of such composition contains often too much sulphur. For such purposes a low grade of pig-iron, with small amounts of manganese or silicon, may be refined in the Héroult furnace; and it does not matter what the content of sulphur is. Dr. Geilenkirchen gives the results of two experiments made in this direction. The figures given in the following analyses under "S before" and "S after," are the sulphur percentages before and after treatment in the electric furnace:—

C.	Mn.	Si.	P.	S before.	S after.
3.00	0.69	2.17	0.468	0.496	0.005
3.09	0.57	0.49	0.356	0.450	traces.

In the first case the percentage of carbon was reduced in the electric furnace by addition of scrap.

The Roechling-Rodenhauser Furnace.

Professor B. Osann, in his essay based on experiments with the Roechling-Rodenhauser furnace, also emphasises that the removal of sulphur in the electric furnace is essentially due to the formation of calcium sulphide. His experiments were made with molten soft steel of 0.1 per cent. C.

In the first period of the treatment the phosphorus is removed. This may be successfully done by means of lime and roll scale. Lime alone or lime and manganese ore do not give satisfactory results. The removal of phosphorus by oxidation requires evidently a substance giving off oxygen, in this case iron oxide. Until the phosphorus is removed, it is therefore impossible to begin with carburisation. Further, since removal of sulphur is possible only with a slag free from iron, desulphurisation cannot start at an earlier moment. Carburisation is carried out by charging retort coal in bags. Desulphurisation requires a slag made from lime and fluorspar, with additions of ferro-silicon. The refining process consists, therefore, of three steps; removal of phosphorus, carburisation, and removal of sulphur. The latter two steps may start simultaneously.

Of the eight runs described by Professor Osann the following two are reproduced in Table I. because they represent normal operation. In the first period of the process, as shown in the table, the phosphorus is reduced to the desired amount. The fact that after this first period the phosphorus slightly increases again is due to the silicon addition. The old slag from the dephosphorisation period had not been completely removed and the phosphoric acid in it was reduced by the silicon, so that phosphorus returned into the steel bath.

Concerning the reactions by which sulphur is removed, there was some uncertainty in the past. It was first tried to remove the sulphur by means of lime to which fluorspar was added to get a fluid slag. It was not known at that time that a slag practically free from iron was absolutely necessary. The successful removal of sulphur requires a slag of lime and fluorspar with additions of ferro-silicon.

As soon as the dephosphorisation slag has been removed, ferro-silicon in large pieces (of egg size) is charged (together with the carbon for deoxidation). After a slag has been formed, the same ferro-silicon alloy, reduced to pea size, is thrown on the slag and this is repeated until the desired result is obtained.

The quantity of ferro-silicon charged in large pieces is so proportioned that the bath would contain about 0.5 per cent. silicon if there were no losses. Only for steels, the silicon content of which must be low, less ferro-silicon is used. The author always used 50 per cent. ferro-silicon. The ferro-silicon is first charged in large pieces because its action is intended to extend over a longer period.

The two charges 1 and 5, about which details are given above, represent normal methods of working for hard steel and soft steel respectively.

Other comparative charges, described by Professor Osann, show that the sulphur is not removed if ferro-manganese is substituted for ferro-silicon. The results are still more unsatisfactory if lime and fluorspar alone are used (or with some sand) without ferro-manganese or ferro-silicon.

TABLE I.

Run 1 (Hard Steel).	Composition. C.	Mn.	Si.	P.	S.
After treatment with roll scale ...	0.105	0.204	0.016	0.012	0.069
Addition of 5 kg 50% ferrosilicon (egg size) and 15 kg coal. Slag made from 10 kg lime and 4 kg fluorspar. When slag was fluid, the composition of bath was ...	1.07	0.248	0.092	0.020	0.044
5 kg lime, 2 kg 50% ferrosilicon (pea size) and 2 kg fluorspar thrown on slag	1.07	0.234	0.096	0.013	0.028
Since the slag was still dark, another addition of 1 kg 50% ferrosilicon and 1 kg fluorspar was made. The colour of the slag became lighter	1.07	0.463	0.19	0.015	0.016
Again 2 kg 50% ferrosilicon and 2 kg fluorspar added. The slag now white. Furnace tilted	1.05	0.263	0.25	0.016	0.008
Composition of the last slag: 28.66 SiO_2, 43.30 CaO, 2.59 FeO, 0.70 MnO, 0.45 S, iron 2.22.					
Run 5 (Soft Steel).	C.	Mn.	Si.	P.	S.
Charged	0.139	0.435	0.014	0.053	0.053
After treatment with roll scale (15 kg) and lime, and removal of slag	0.109	0.406	0.016	0.026	0.053
Charged 6 kg 50% ferrosilicon (egg size) and slag made from 15 kg lime and 6 kg fluorspar. 10 kg of pea size ferrosilicon added ...	0.141	0.406	0.35	0.031	0.020
Some time later...	0.127	0.406	0.34	0.031	0.016
Composition of last slag: 19.48 SiO_2, 63.70 CaO, 2.8 Al_2O_3, 5.44 MgO, P trace, 1.47 S, 0.77 FeO, 0.54 Fe_2O_3, 0.98 total iron, 0.09 total manganese.					

Analyses of the Slags.

The analyses of the slags given for the different charges show clearly the relation between iron content of the slag and sulphur content of the bath. If the slag contains considerably more than 2 per cent. of iron, the removal of the sulphur is unsatisfactory.

Professor Osann concludes that an iron content in the slag prevents desulphurisation of the steel bath, on account of the reaction $FeO + CaS = FeS + CaO$, which is strongly exothermic reaction. He emphasises

the difference between removal of sulphur as manganese sulphide and as calcium sulphide. Sulphur is removed as manganese sulphide in the mixer. A content of ferrous oxide in the slag is not detrimental in this case (because the reaction $FeO + MnS = FeS + MnO$ evolves so little heat at ordinary temperature that it may be assumed to proceed in the opposite direction at higher temperature). A complete removal of sulphur is, however, impossible in this way. It requires the formation of calcium sulphide.

A substitute for lime has not yet been found. Alkali metals, which are preferably employed as carbonates (not as chlorides), are effective, as experiments in Voelklingen have shown. But they are expensive and destroy the brickwork of the furnace.

The use of magnesia (which comes any way from the furnace walls into the slag) is not successful, nor the use of manganese oxide. A high content of manganese in the steel bath (up to 1 per cent.) has no influence on the sulphur content below 0.05 per cent.

To reduce the iron oxides in the slag, only ferro-silicon has been found effective, besides carbon, which alone, however, is insufficient. The high oxidation heat of silicon manifests itself by inducing the reaction $2\,FeO + Si = 2\,Fe + SiO_2$ and producing a high temperature in the slag. Manganese is no efficient substitute, nor has calcium carbide been found effective in the induction furnace. The formation of calcium carbide (which is easily detected by the smell of acetylene when the white slag disintegrates or is wetted) must, therefore, be considered to be simply a secondary phenomenon. A high temperature helps the removal of the sulphur.

Professor Osann finally remarks that possibly a gaseous compound, silicon sulphide, plays a part. This is not impossible, but has not yet been proved.

British Foundrymen's Association.

Lancashire Branch.

The annual meeting of the Lancashire Branch was held in the School of Technology, Manchester, on Saturday, April 3, Mr. R. W. Kenyon presiding.

Following the Secretary's report, which stated that the series of papers read during the session had been of first-class scientific and practical importance, and had developed more usefulness in the form of discussion than previously, the following officers for the coming year were appointed:—President, Mr. R. W. Kenyon, Accrington; Vice-Presidents, Mr. G. Buchanan, Wrexham; Committee, Messrs. T. W. Holt, J. Kenyon, T. W. Markland, J. Penlington, W. H. Sherburn, J. Simkiss, H. S. Skelton, and W. Wright; Hon. Secretary, Mr. H. Sherburn, Warrington.

Important matters concerning the future of the Branch were discussed, and dates were arranged for visits to the works of Messrs. Musgrave & Sons, Limited, Bolton, and the Locomotive Works of the Lancashire and Yorkshire Railway Company, Norwich, in accordance with their kind offers.

It was decided to hold the next annual dinner in October. An extra meeting was also arranged for Saturday, May 1 to hear a paper by Mr. Penlington, which had been unavoidably postponed.

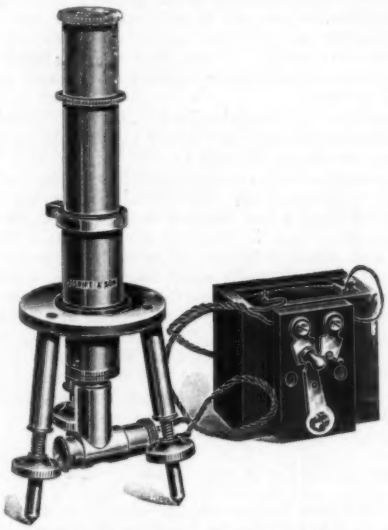
Votes of thanks to the officers for their services during the past year concluded the business of the meeting.

A Workshop Microscope.

The microscope shown in the accompanying illustration was designed by Mr. J. C. Stead, F.R.S., for the convenience of engineers, iron and steel founders and other workers in metals, who occasionally require, in their workshops, the use of a compound microscope of the most simple form. As the metal objects examined are opaque, the necessity of any substage apparatus is avoided.

The stand, as may be seen from the illustration, is mounted on a tripod base. The legs of this tripod may be lengthened or shortened, by rotating the milled heads on them, in order to compensate for any unevenness of the surface of the object under examination. The lower ends of the legs are fitted with hard steel points.

For focussing the optical tube slides in a cloth lined fitting through the centre of the plate of the tripod; when the focus has been found the tube may be fixed by a small clamp-screw.



A Simple Microscope for the Foundry.

The silvered reflector is placed in an argular slit in the objective, to which a small electric lamp is so attached, that when the current, from a portable dry battery, is turned on, the object is perfectly illuminated. The battery is contained in a small wooden case fitted with a switch.

This apparatus has been supplied to the Royal Arsenal, Woolwich, and to many large firms at home, on the Continent, and in America.

The makers are Messrs. James Swift & Son, of 81, Tottenham Court Road, London, W.

A statement that Babcock & Wilcox, Limited, contemplate a capitalisation of the company's reserve fund, which stands at £400,000, has been officially denied.

Under the auspices of the Bradford Engineering Society a lecture was delivered recently at the Technical College by Mr. Percy Longmuir, of Sheffield, on "Cast-Iron." Mr. H. W. Morley presided over a fairly large attendance. In the discussion which followed, it was suggested that a branch of the British Foundrymen's Association should be formed in Bradford.

Bronze in South America before the Arrival of the Europeans.

Until recently doubts have existed as to the use of an actual alloy of copper and tin in South America before the conquest by Europeans, for there was a lack of exact data in regard to the composition of the metal from which objects collected by archæologists were made, and, also, there was lacking positive evidence as to the existence in those regions of very rich tin-bearing deposits, which are to-day actively exploited. M. Adrien de Mortillet, Honorary President of the Société Prehistorique de France, has, however, published the results of certain chemical analyses made on some fifty specimens, different in nature and origin, which furnish decisive proofs regarding the use of such alloys in the South American continent. The first series of analyses were made on objects collected from the ancient ruins of Tiahuanaco, near Lake Titicaca, north of the high Bolivian plateau; in the vicinity of Yura, between Uyani and Potosi; from the Republic of Eucador; from localities north of the Argentine Republic, between Salta and the Bolivian frontier. The second series of analyses relate to objects discovered in the valleys along the eastern side of Cordillera, north-west of the Argentine Republic.

The objects included bolts in the form of a double T, used to bind stones in walls; knives with perpendicular tangs in the centre of their blades; circular pieces of thin sheet metal; pins with large flat heads; flat, thin axes; heavy, thick axes; bells shaped like the flattened body of a cone; metal rods with one end sharpened; an axe with a large, thick tang, and other objects. The results of a few of the analyses are tabulated herewith:—

Region.	Object.	Copper	Tin.	Lead.	Zinc.	Antimony.	Iron.	Sulphur
Bolivia ...	Bolt ...	98.64	—	—	—	—	0.43	0.87
,, ...	,, ...	95.65	—	0.12	—	Tr.	1.63	2.55
,, ...	Knife	93.10	5.83	0.63	—	0.06	0.36	—
,, ...	Pin ...	91.41	7.70	0.30	—	0.11	0.41	—
,, ...	Axe ...	97.23	2.10	0.12	—	0.16	0.37	—
,, ...	Plate	59.20	—	—	39.33	—	1.33	—
Eucador ...	Axe ...	99.43	—	0.22	—	—	0.27	—
Argentina	Chisel	99.70	—	0.08	—	—	0.17	—
,, ...	Disc...	97.02	2.48	0.11	—	—	0.31	—
,, ...	Knife	95.97	3.65	0.13	—	—	0.21	—
,, ...	Bell ...	95.60	3.92	0.14	—	—	0.29	—
,, ...	Ball ...	89.85	9.40	0.32	—	—	0.41	—
,, ...	Axe ...	91.40	7.38	—	—	—	1.05	—
,, ...	,, ...	93.58	6.06	Tr.	—	—	—	—
,, ...	Disc ...	94.57	5.43	Tr.	—	—	—	—
,, ...	,, ...	83.47	16.53	—	—	—	—	—

An examination of the analysis of all the objects treated showed that six were of copper, forty-one of bronze, and one of brass. Three of the copper pieces were nearly pure, containing more than 99 per cent. copper, and only a few tenths of 1 per cent. of lead and iron. Like all products of a primitive metallurgy, the bronze objects contain, besides copper and tin, certain other metals, but in very small proportions. The majority of the analyses showed lead (from 0.07 to 1.80 per cent); in only two specimens was more than 1 per cent. found. Zinc was discovered in several discs from Argentina to the extent of 0.81 to 1.65 per cent. Antimony was encountered in very small quantities, but quite uniformly, in all the Bolivian bronzes, the amount generally being 0.06, and rarely up to 0.17, while it was totally lacking in those from Argentina. Bismuth, in quantities from 0.23 to 0.82, was found in several of the Argentine bronzes, while in two specimens of the same origin nickel was present in percentages of 0.78 and 2.04. Silver also was scarce, one specimen having 0.22 per cent., and two others only a trace. Iron, on the other hand, was contained in nearly all the bronzes analysed, in proportions varying from 0.08 to 1.79 per cent., the majority containing less than 1 per cent. It is evident that the iron, as well as the other accessory metals just mentioned, were not introduced intentionally into the composition of the bronzes. They were probably found naturally either in the copper and tin ores used, or in the attle around these ores.

The proportions of copper and tin in these bronzes were very variable. The specimens from Tiahuanaco contained from 5.83 to 7.70 per cent. of tin, while those from Yura contained from 2.10 to 10.72 per cent. In the bronzes from Argentina the variance in the tin content was still greater, being from 1.57 to 16.53. Altogether, of forty-one pieces examined, only four were found to contain more than 10 per cent. of tin—the normal proportion in bronze. The mixture of these two metals was certainly intentional. It furnishes irrefutable evidence that the tribes living in the mineral-bearing regions of the Bolivian and Argentine Andes, before the advent of the Europeans, were familiar with tin, and that they knew how to extract and alloy with copper. But the unequal proportions of tin shown in their bronzes demonstrates that they possessed only quite rudimentary ideas on the metallurgy of this latter metal.

The refining of metals was very imperfect, and the combination of the constituents rather empirical, for it is not in the objects in which a large proportion of tin would have been particularly useful that the greatest percentage occurs. In the metal of a knife from Tiahuanaco, for instance, only 5.83 per cent. of tin was found, while a pin contained 7.70 per cent. From Yura, also, a very thin cutting axe had in its composition only 1.10 per cent., while two other objects that were purely for decorative purposes contained up to 9.30 and 10.72 per cent. of tin. In the case of some of the Argentine bronzes a knife contained only 3.65 per cent. of tin, while a bracelet had 13.69 per cent.

STEEL PRODUCTION OF CANADA.—The returns for the past year from eight companies making steel showed a total output of ingots and castings of 588,763 short tons, valued at $9,233,602, as compared with 706,982 tons, valued at $15,612,590 from seven companies in 1907. These figures are made up as follows:—

	1907.		1908.	
	Tons.	Dols.	Tons.	Dols.
Ingots—				
Open-hearth (basic) ...	450,240	9,157,703	443,442	6,001,277
Bessemer (basic) ...	225,989	4,293,791	135,557	2,535,287
Castings—				
Open-hearth (acid and basic)	20,602	2,031,380	9,051	617,126
Other steels	1,151	129,716	713	79,912
	706,982	15,612,590	588,763	9,233,602

Analysis of Cast Iron.

British Foundrymen's Association :: Lancashire Branch.

Before the Lancashire Branch of the British Foundrymen's Association recently a paper on the above subject was read by Mr. H. P. Mason. We reproduce the paper herewith :—

The average foundryman using grey iron has in the past placed too much reliance on the chemical analyses and assertions of the pig-iron manufacturers, who are supposed to know all about the quality of their products. Although chemists are extensively employed by these makers, their time is usually too fully occupied in analysing the raw materials used in the blast-furnace for them to devote much attention to their finished product. Certain daily routine analyses are made to estimate the silicon and phosphorus; but in the abstract the maker has no very deep knowledge of the material he is selling, although, on the whole, he has more than his customer, the foundryman. There are, however, exceptions. In a separate class are a small minority of makers who can conscientiously supply metal to analysis. In another class are, for instance, makers producing iron for steel making to specified analysis, who generally have an excellent knowledge of their iron, sometimes to the detriment of the ironfounder, who may be supplied with such material as is unsuitable for the steel works. The material supplied may or may not suit the founder, according to his class of work. There are other makers with foundries of their own who will not invariably retain for their own consumption, the "kishy" or other unsuitable iron made by them.

Constituental knowledge, obtained first-hand, is consequently to be preferred, and this paper is an attempt to give foundrymen an idea of the simplicity and celerity with which reliable technical chemical analyses can be obtained, paying due regard to practical difficulties. Sometimes more is expected of chemical analysis than it is able to perform, yet, if properly applied, even in the present unsatisfactory state of our knowledge, it is necessary to the economical running of a foundry, as it ensures intelligent mixing, enables advantage to be taken of varying market prices, and facilitates the selection of better quality pig often at no increase in cost. It disperses the glamour which in many cases envelops high-priced irons of indifferent quality, so that they may be dispensed with. By its aid many machining problems are solved, and in some cases wasters, which without reason are put down to bad iron, are traced to an entirely different source.

With the actual manufacture of the pig-iron, the foundryman has little or no concern. Generally, the molten metal is cast from the blast-furnace under varying climatic conditions, in open sand moulds, at temperatures which vary with the working of the furnace. What the fracture of the iron really shows is its state of crystallisation, which is determined by its rate of cooling, and, under the conditions ruling on the pig-beds, to a lesser extent by its composition.

To emphasise this point, the limits of a considerable number of partial analyses made by the writer, of correctly graded No. 3 iron of the same brand, may be given, particular attention being directed to the total carbon and silicon contents.

	Per cent.	
Total carbon	2.75 to 3.50	
Silicon...	1.80 to 4.00	
Sulphur	0.04	
Phosphorus	1.30	Average
Manganese	1.80	

Phosphorus and manganese vary according to the raw materials used, and differences in the amounts of these elements in the same brand will occasionally be found to be considerable, although as a rule they are fairly constant. The silicon will often vary as much as 1 per cent. in the same cast. Fracture and silicon contents seems to be a favourite combined basis for pig-iron specifications, and the writer was at one time inclined to regard this as ideal, but further experience has convinced him that total carbon and silicon with limitations to the other constituents (practically a complete analysis), would be preferable. The practical difficulties are such as could be overcome; the real difficuty the maker would have to contend with would be finding a market for his unsuitable metal.

A pig from the middle of each bed of the cast of iron is usually selected and broken, and the iron in the bed shipped according to the fracture of the broken pig.

In sampling pig-iron from a truck, it is advisable to take samples from pigs at different ends of the truck, as the iron may even be from different furnaces. The writer has found a variation of 1 per cent. manganese (an element which does not usually vary much) in pigs from the same truck. Even from the different parts of a fracture of a pig we find a variation in the quantities of the elements, due to segregation, and it will be seen that sampling pig-iron is by no means the easy thing it appears on the surface. To obtain a representative sample the following method is advocated, which the writer has used with success for several years:—A piece should be broken out of the middle of a pig and sand-blasted to remove sand from the skin, the presence of which in the sample would interfere with the analysis, and especially so with the silicon estimate. A $\frac{3}{4}$-in. drill should be used to take off the skin, and drillings then taken with a $\frac{1}{2}$-in. flat drill from the round to the flat side. (A flat drill is to be preferred to a twist drill on account of the drillings being obtained in a finer state of division.) All the drillings should be placed in a suitable bottle, and mixed by being well shaken. What is required in a chemical estimate of pig-iron is not so much the absolute scientific accuracy of a single analysis as a number of results, giving an idea of the average composition of the iron and the limitations of various constituents. To obtain these analyses, there are certain essentials:—The methods used must not be too costly, must be reliable, as rapid as possible consistent with accuracy, and not require too much attention to work them.

The apparatus required in an iron works laboratory is not of an expensive nature. A good short beam balance, a rough balance, a still for pure water, a gas muffle furnace for ignitions, and a level cast-iron plate, about 3 ft. by 2 ft., and $\frac{1}{2}$ in. thick, heated by a tube burner, for evaporations, are essential. The muffle and plate should be placed in a cupboard preferably lined with glazed bricks, and fitted with a positive draft to convey away acid fumes; and a compartment isolated from the working room should be provided for the balances. Bottles, beakers, burettes, flasks, funnels, and other incidental apparatus are required, but £70 should cover the cost.

Before the chemist can say how much of any element exists in the sample submitted to him, it is necessary that he use some means of separation, or change into some form which can be measured the element he is to determine. To attain this end, certain properties of reaction are made use of. Chemical change is most complete when the interacting substances are in the state of gas or miscible liquids, and least perfect between solids. So the aim of the analyst is to first bring his material into the liquid form, as being most convenient, and then, by the addition of other suitably-selected substances, he can change the state of the element he wishes to determine into some form in which he is able by other chemical reactions to measure the amount present, or, if the change is into the solid state, to mechanically separate and measure it.

This mechanical separation is one of the most important operations the iron analyst has to deal with.

The old stereotyped method of filtering through a cone of folded paper is only used in cases where the filter must be dry. Filtration through layers of paper pulp or asbestos is the course generally adopted. A special crucible invented by Gooch is largely used, and attention might be drawn to a form of filter tube, designed by the writer, which is very useful for routine estimations. In this tube the stem is separate from the body and is ground in, so that it is held in position and forms a ledge on which a porcelain filter disc can rest. This disc carries a felt of ashless paper pulp which retains the solid particles. The stem, being made slightly longer than the tube body, can be used to eject the filter felt, which, in its passage down the tube, effectually removes and carries with it any particles adhering to the sides.

The elements usually determined in iron are graphite, combined carbon, silicon, sulphur, phosphorus, and manganese; and the liquid state necessary for their separation is that of solution, which is produced by the chemical action of acids changing the metal into soluble salts. The acids used to effect solution are nitric, hydrochloric, and sulphuric acids, used separately or in mixtures.

Strong nitric acid has very little action on iron, but dilute nitric acid, specific gravity 1.20, containing about 34 per cent. true nitric acid, attacks it violently, converting the iron present into soluble ferric nitrate, and manganese into soluble manganous nitrate. Combined carbon is dissolved and imparts a brown colouration to the solution, but the graphite remains undissolved. Silicon is retained in solution, but is apt to become precipitated as gelatinous silicic acid on continued boiling of the solution.

Estimation of Manganese.

A method worked out by Reddrop and Ramage, and modified by Ibbotson and Brearley, is the ideal method for the estimation of manganese. This is known as the bismuthate method. The principle is, that the manganese is oxidised to permanganic acid in a cold nitric acid solution. Permanganic acid being of itself an oxidising agent, an excess of a ferrous salt is added, which it can oxidise to the ferric state, and by measuring the amount unacted upon, the manganese can be determined. The details are as follows:—

Time taken, 20 minutes. Solutions required: 39.2 grams of ferrous ammonium sulphate is dissolved in water containing a little sulphuric acid, and diluted to 1 litre at normal temperature. 1 c.c. = 0.1 per cent. of manganese on 1.1 gram of iron. 3.16 grams of potassium permanganate is dissolved in water, and diluted to 1 litre. 1 c.c. = 1 c.c. ferrous sulphate solution. 1.1 gram of the sample is weighed (this weight bears a relation to the strength of the measuring solutions), and transferred to a 250 c.c. covered beaker. 50 c.c. nitric acid (1.2) is added and boiled. The manganese, iron, and combined carbon pass into solution; but the graphite remains suspended, and is removed by filtration through paper pulp. The filter is washed, the filtrate cooled, and excess of sodium bismuthate added, which oxidises and removes any combined carbon, which would interfere. The solution is again boiled, and a few drops of sulphurous acid added to dissolve a slight brown precipitate of hydrated manganese oxide. To the cooled solution about 2 grams of sodium bismuthate is added, which converts the manganese present into permanganic acid. The excess of bismuthate is filtered off through an asbestos filter, and the filter washed with dilute nitric acid until free from colour. Excess of the ferrous sulphate solution is run in to discharge the colour, and potassium permanganate solution added until a pink tinge is again seen.

Example.—15 c.c. ferrous sulphate used
1 c.c. permanganate solution used
15 − 1 = 14 + .1 = 1.4 per cent. manganese.

Estimation of Carbon.

Iron will dissolve in an acid solution of a copper salt and leave a solid residue consisting of all the carbon present in the iron. The solution used consists of a saturated solution of potassium cupric chloride containing 5 per cent. of free hydrochloric acid.

The carbonaceous residue can be collected on an asbestos filter, washed, dried, and ignited in a current of air or oxygen, which has been previously freed from carbon dioxide and water, by treatment with potash hydrate solution and sulphuric acid. The products of combustion are passed over ignited platinised asbestos, or copper oxide, to ensure that the carbon is thoroughly converted to the dioxide, which gas, after being purified and dried, is absorbed in a tared tube containing soda lime. The carbon dioxide is known to contain 27.27 per cent. of carbon, and the weight of iron taken for the analysis being known, the amount existing in the metal can be calculated.

The graphite, remaining insoluble in dilute nitric acid, can be determined in a similar manner, and the difference between the total carbon and the graphite will give the combined carbon. Special apparatus is required. The writer uses a series of Arnold bulbs for purification and drying, the combustion tube being of porcelain containing about 6 in. of packed platinised asbestos, which is heated in a Huxley furnace.

This method roughly outlined is known as the combustion method, and leaves nothing to be desired when used by trained analysts working on homogeneous material, but cast-iron drillings are not homogeneous, so far as the carbon is concerned, and the difference in the specific gravities of graphite and iron causes very erratic results to be obtained, the error being thrown on the combined carbon. If the graphite is sieved off, and only the coarser particles taken for analysis, the results are satisfactory in regard to the sample. Determinations of combined carbon by combustion, working on sieved drillings are made, and the drillings are then used as standards in the following method for its estimation.

The following method was suggested by Professor Eggertz, of the Swedish School of Mines, and is based on the comparison of the depth of the brown colouration imparted to the solution by the combined carbon existing in the sample, with that produced by a known amount of carbon in a standard, when the metal and the standard are dissolved in 1.2 nitric acid.

Method:—Time taken, 30 minutes.

For castings, an iron containing about 4 per cent. of combined carbon is suitable for a standard, other standards being required for pig. One gram of the standard of known combined carbon contents, which are approximately those of the material to be tested, and the same weight of drillings, are weighed into 7-in. by 1¼-in. test tubes. 30 c.c. of 1.2 nitric acid is added, and the solutions heated in boiling water for 20 minutes. At the end of this time they are cooled, and transferred to 50 c.c. graduated flasks, diluted to the mark, well mixed, and filtered through dry filter papers (Munktell's No. 1 F, 11 c.m.). The filtered solutions are then poured into burettes and compared in a colour gauge, which consists of two carefully selected test tubes of similar bore placed in camera, the lower ends of the tubes being immersed in water to eliminate concentric rings. White light is reflected from below and transmitted through the liquids placed in the tubes. The colours are equalised, and the quantities of each liquid used, and ascertained from the readings of the burettes, are in inverse ratio to the carbon present. The Eggertz method is not generally advised for cast iron, but when modified as above, working on the comparatively large quantity of drillings, it is a very reliable method.

There is a form of combined carbon known as hardening carbon, which is not determined by the preceding method, but in grey iron foundry practice the amount is very small, and may be generally ignored. It is estimated by taking the difference between the carbon obtained by combustion of the residue left on dissolving the metal in an acidified copper salt, and that remaining when it is dissolved in very dilute sulphuric acid in a current of coal gas.

Graphite is estimated as follows:—Time taken, 45 minutes. Five grams of the well-mixed drillings is weighed into a 400 c.c. covered beaker, 100 c.c. 1.2 nitric acid is gradually added, and the solution boiled well

until all brown fumes have disappeared. A few c.c. of hydrofluoric acid is added, which will eliminate as gas any gelatinous silica which may be formed, and which would retard filtration. The solution is then filtered through asbestos in a Gooch crucible, and the graphite retained is washed well with water and very dilute ammonic hydrate (1 per cent.) to remove any hydrocarbons, then, with a little dilute hydrochloric acid, and again well with water. The crucible is then dried, a drop of alcohol added, covered, and ignited at a red heat over a Teclu burner, allowed to cool, and weighed. The graphite is then removed by ignition in the muffle and the crucible re-weighed. Loss in weight x 20 = graphite per cent.

These two methods for ordinary foundry work are to be preferred to the combustion methods; they do not require so much attention, and in the hands of young assistants give much better results.

Estimation of Silicon.

Almost every British pig-iron contains small amounts of titanium, and for foundry iron the separation of silicon is best made by a modified Drown method. Drown suggested the use of a mixture of dilute nitric acid and sulphuric acid, which dissolves the iron, and in the absence of titanium, everything except the graphite. On evaporating the solution until fumes of sulphuric acid are evolved, the silicon is precipitated in a form which is easily filtered off with the graphite and separated from it by ignition. A mixture containing hydrochloric acid as well as nitric and sulphuric acids gives better results in the presence of titanium, as a difficultly soluble phospho-titanate of iron is then decomposed and dissolved.

Method:—Time taken, 45 minutes.

Acid Mixture.—To 1,000 c.c. of distilled water, 300 c.c. con. sulphuric is added, and the liquid allowed to cool; 300 c.c. of con. hydrochloric acid is stirred in, and afterwards 100 c.c. of con. nitric acid added. 0.9404 gram of the drillings is weighed into a 250 c.c. lipped, covered Jena beaker (this weight is taken to ensure an easy factor and simplify calculation). 30 c.c. of the acid mixture is added, and the solution evaporated down on the hot plate, until fumes of sulphuric acid are evolved. About 50 c.c. of hot water is added, and 5 c.c. of con. hydrochloric acid, and the liquid boiled. It is then filtered through ashless pulp, washed alternately with hot dilute hydrochloric acid and cold water, ignited and weighed. Silica contains 47.02 per cent. of silicon. Weight of silica x by 50 = silicon per cent.

Sulphur Estimation.

Aqua regia is a mixture of con. hydrochloric and nitric acids. It is really a solution of two gases, nitrosyl chloride, and chlorine, and has a very powerful oxidising action on iron. Sulphur and phosphorus existing in the iron are, when it is dissolved in this agent, converted respectively into sulphuric and phosphoric acids. Iron is converted into ferric chloride; graphite is not affected, and remains in suspension; silicon is converted into insoluble silica on evaporation of the solution to dryness.

In the gravimetric method for sulphur estimation (which is the only reliable method for pig-iron), a solution of chlorides containing a suitable amount of free hydrochloric acid, in which the sulphur exists as a sulphate, is boiled with an excess of a solution of barium chloride. An insoluble precipitate of barium sulphate is formed, which can be collected and weighed, and as this is known to contain 13.7 per cent. of sulphur, that in the metal can be calculated.

Method:—Time taken, 3¼ hours.

3.43 grams is weighed into a 800 c.c. covered Jena beaker; a mixture of acids free from sulphur, consisting of 17 c.c. con. nitric acid and 33 c.c. con. hydrochloric acid, are heated in a small beaker until the solution is of a deep colour, and then added quietly to the drillings. The solution is then evaporated to dryness, and heated strongly for 30 minutes. It is re-dissolved in 40 c.c. of con. hydrochloric acid, and the graphite and silica are removed by filtration through paper pulp, and the filter washed with cold water. The filtrate is transferred to the original beaker and evaporated to remove most of the acid (until a "skin" forms). 5 c.c of hydrochloric acid is then added, and 30 c.c. distilled water, the solution is re-filtered through pulp, and washed free from iron salts, keeping the bulk of the liquid as low as possible. The solution is then boiled, 30 c.c. of a boiling 10 per cent. solution of barium chloride added and digested at about 95 deg. C. for two hours, when the precipitation is complete, but is generally allowed to remain over night. It is then filtered through ashless pulp, washed thoroughly with water and dilute hydrochloric acid, ignited and weighed.

The weight of barium sulphate (after deducting any weight which may be due to sulphur existing in the acid used which has been separately estimated) x by 4 = sulphur per cent.

This is the most troublesome of the elements to estimate in an ordinary complete analysis. The writer's experience is that the sulphur in the coke used for melting is a much greater factor for evil than that existing in the pig: but the regular estimation in pigs which show combined carbon above the average will often repay the trouble taken.

Phosphorus Estimation.

In solutions containing a little free nitric acid, ammonium nitrate, and orthophosphoric acid, phosphorus is precipitated by a nitric acid solution of molybdic acid, as a canary-coloured compound, ammonium phosphomolybdate, which, when dried at 100 deg. C., contains 1.63 per cent. of phosphorus.

Method:—Molybdic Reagent.—50 grams of molybdic acid is dissolved in 80 c.c. ammonic hydrate and 120 c.c. water. To this solution is quickly added 750 c.c. of 1.2 nitric acid.

One gram is weighed into a 400 c.c. covered, lipped beaker, and dissolved in 25 c.c. aqua regia, which is made up as required, evaporated to dryness and baked, re-dissolved in 20 c.c. hydrochloric acid, evaporated to low bulk, diluted and filtered through pulp to remove graphite and silicon. The filter is washed with dilute hydrochloric acid and water. Decided excess of ammonic hydrate is added, and the solution just cleared with con. nitric acid. 50 c.c. of the molybdic reagent is added, the solution well shaken and allowed to settle. It is then filtered through a tared Gooch crucible containing a dried pulp filter, washed with 2 per cent. nitric acid, and dried at 100 deg. C. Weight of precipitate x by 1.63 = phosphorus per cent.

Instead of weighing the yellow precipitate it may be treated by the process proposed by Handy, which is an excellent method for routine work.

Method:—Time taken, one hour.

Caustic soda, free from carbonate.—12 grams of pure sodium hydrate is dissolved in distilled water, a little barium hydrate solution added to precipitate any carbonate which may be present in the solution, which is diluted to 2 litres. This is allowed to stand overnight and filtered. 1 c.c. = 0.02 per cent. P. (approx.).

Nitric acid.—18 c.c. con. nitric acid is diluted to correspond with the caustic soda solution.

Phenolpthalein.—0.1 gram is dissolved in 100 c.c. alcohol.

Potassium nitrate.—250 grams is dissolved in 1 litre of water.

The precipitate obtained from 1 gram of the drillings is filtered through an 11 c.m. Munktell No. 1 paper, washed well with 2 per cent. nitric acid, and the saturated solution of potassium nitrate to remove the acid. It is then washed off the paper into a 300 c.c. registered flask. Excess of the caustic soda solution (which has been previously standardised on a material of known contents) is run in. ½ c.c. phenolpthalein is added, and the pink colour just discharged with the nitric solution.

Estimation of Titanium and Other Elements.

Such are methods used for the estimation of the common elements in cast-iron which have the chief effect on its physical properties, and a so-called complete analysis can be easily obtained in a working day,

but it is often forgotten that other elements exist which may have a decided influence. Titanium and vanadium are constituents in almost every sample of British pig-iron, but are not determined as they ought to be; for, with the knowledge we have of the increase in strength produced by the addition of small amounts of these elements to cast iron, it would be rash to assert that they are without influence, when irons containing them are mixed with irons which may be practically void.

Titanium in nitric acid solution gives a brown colouration with hydrogen peroxide, but this simple method, unfortunately, cannot be used for cast iron, as titanium is in British irons invariably accompanied by vanadium, which gives a reddish colouration with the same reagent.

Titanium in the presence of phosphorus is left as an insoluble phospho-titanate of iron, when iron containing it is dissolved in hydrochloric acid. This compound, when fused with potassium carbonate, is decomposed into insoluble potassium trititanate, which may be rendered soluble by fusion with potassium bisulphate; titanic acid being precipitated from a reduced solution.

Method :—Five grams of the drillings, and, in the case of a non-phosphoric iron, ½ gram of ammonium phosphate crystals, are dissolved in hydrochloric acid, and evaporated to dryness to render the silica insoluble. The dried mass is re-dissolved in hydrochloric acid, diluted and filtered through pulp. The filter is washed well with dilute hydrochloric acid and cold water and transferred to a platinum crucible. It is then ignited to remove graphite, and the silica is eliminated by evaporation to dryness with about 4 c.c. of hydrofluoric acid, and two drops of sulphuric acid. The residue is then fused with excess of potassium carbonate and treated with hot water, which removes the phosphorus and leaves the trititanate of potassium insoluble. This is filtered through pulp, and the filter after being washed is ignited and fused with excess of potassium bisulpate. The fusion is then extracted with hot dilute hydrochloric acid, a few c.c. of sulphurous acid is added, and the solution boiled. The titanium will be precipitated as a fine cloud, and would require long boiling for its completion, but if the free mineral acid is replaced by acetic acid, by the addition of an excess of hot ammonium acetate, the titanium is at once precipitated and can be filtered off through an ashless filter, washed and ignited to titanic acid, which contains 60 per cent. titanium.

Vanadium.

Vanadium may be readily estimated volumetrically. The solution of vanadic acid in sulphuric acid is reduced to tetroxide by sulphurous acid, and re-oxidised by means of standard potassium permanganate.

Method :—Potassium permanganate solution: 1.234 grams of the salt dissolved in 1 litre of water. 1 c.c.= 0.02 per cent. vanadium on 10 grams of sample. Ten grams of the drillings is dissolved in 500 c.c. of dilute sulphuric acid (1 to 10), without access of air, filtered, and well washed with hot water. The filter is then ignited, mixed with an excess of sodium carbonate, and fused. The melt is dissolved in hot water, filtered, and the filtrate after acidifying with sulphuric acid is reduced with a little sulphurous acid. The excess of sulphur dioxide is boiled off and the solution titrated with permanganate, re-reduced, and retitrated

Small amounts of copper, arsenic, and chromium, are often present, and may not be of much account, but such cannot be said of the two to five hundredths of 1 per cent of hydrogen, nitrogen, and an even smaller quantity of carbon monoxide, which are present, and are, no doubt, the cause of sponginess and scattered iron. A chemical determination in the drillings is no guide to the amount of these gases originally present in the metal, as gas is set free during the drilling operation.

Parry, in 1883, found that roughly the gases in grey pig-iron consisted of, by volume :—Hydrogen, 75 per cent.; carbon monoxide, 3 per cent.; and nitrogen, 5 per cent.; and no doubt his method of heating the metal *in vacuo* would have to be adopted if reliable results in gas determination were deemed necessary. From one volume of grey pig he found as much as 21 times its volume of gas.

The gas chiefly consists of hydrogen, and the use in this country of desiccated blast which has given such good results in blast-furnace practice in America, and also, too, in the Bessemer process, will possibly be a step in the direction of obtaining iron free from hydrogen.

A complete analysis recently made by the writer of a No. 3 Derbyshire pig gave :—

Graphite carbon	2.90
Combined carbon	0.20
Hardening carbon	—
Silicon	3.00
Sulphur	0.05
Phosphorus	1.35
Arsenic	0.02
Manganese	0.46
Copper	trace
Chromium	0.06
Vanadium	0.16
Titanium	0.23
Nitrogen (evolved as ammonia)	0.01
Nitrogen (fixed as ammonia)	trace
Hydrogen	trace
Oxygen	—
Iron (by difference)	91.53

The Imperial International Exhibition at Shepherd's Bush.

In connection with the above Exhibition, which will be open about the middle of the present month, committees have been formed to advise the administration as to the exhibits relating to mining and metallurgy. These honorary advisory committees are constituted as follows:—Engineering Section (General Mechanical Engineering Committee): Chairman, Captain H. Riall Sankey; vice-chairman, W. Worby Beaumont, F. S. Courtney, and Harry Shoosmith; other members, Sir J. Fortescue Flannery, Bart., Dugald Clerk, John A. F. Aspinall, James Adamson, Percy R. Allen, A. S. E. Ackermann, C. C. Braithwaite, Reg. S. Clay, Walter T. Dunn, J. H. Evers, E. R. Grove, N. W. Hoskins, Geo. H. Herbert, R. Hood Haggie, G. T. Harrap, Robert Harvey, Walter Hunter, F. D. Johnson, L. A. Legros, J. G. Lorrain, Michael Longridge, James P. Maginnis, F. S. Norton, Mervyn O'Gorman, W. Cooper Penn, W. H. Prescott, C. J. Seaman, Alfred Saxon, John F. C. Snell, C. Liddell Simpson, C. J. Fairfax Scott, W. N. Twelvetrees, T. Woof, F. J. Warden-Stevens, H. D. Wilkinson, Walter Yates; secretary and managing engineer, W. Yorath Lewis; administration offices, Macfarlane Road, Shepherd's Bush, W. Mining and Metallurgical Sections: Mining—Chairman, Professor W. Galoway; vice-chairman, Bedford McNeill; Professor John Cadman. A. G. Charleton, Professor S. Herbert Cox, H. W. Hughes, C. McDermid, Professor D. A. Louis, A. L. Pearse, John Roberts, Edgar Taylor, R. Arthur Thomas. Metallurgy—Chairman, Arthur C. Claudet; vice-chairman, George T. Holloway; Professor H. Bauerman, J. J. Beringer, J. H. Darby, E. F. Law, G. C. Lloyd, Richard Pearce, J. E. Stead, H. L. Sulman, Hubert S. Thomas, Professor T. Turner, W. G. Wagner; Hon. Secretary to both Committees, George T. Holloway, 57, Chancery Lane, London, W.C.

The New Open-Hearth Steel Plant of the United States Steel Corporation.

We are able to present herewith some particulars of the open-hearth steel plant installed at the new Gary Works of the Indiana Steel Company, a subsidiary of the United States Steel Corporation. The first heat from the new open-hearth furnaces at Gary was poured on February 2 last. The open-hearth buildings are ranged in a line parallel to and immediately west of the electric power stations, and conforming to a scheme for obtaining easy curves in the trackage system and so economising space, these buildings are set at an angle of 35 degrees with the main north and south trunk lines.

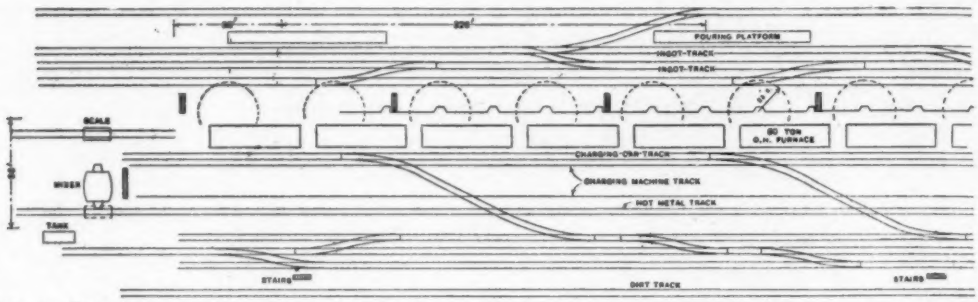


FIG. 1.—PART PLAN OF ONE OF THE OPEN-HEARTH BUILDINGS: TYPICAL OF THE GENERAL ARRANGEMENT.

This arrangement, which is an innovation in such construction, greatly facilitates the speedy transfer of hot metal from the blast furnaces, from which it is taken direct to the mixers on ladle cars in 40-ton ladles.

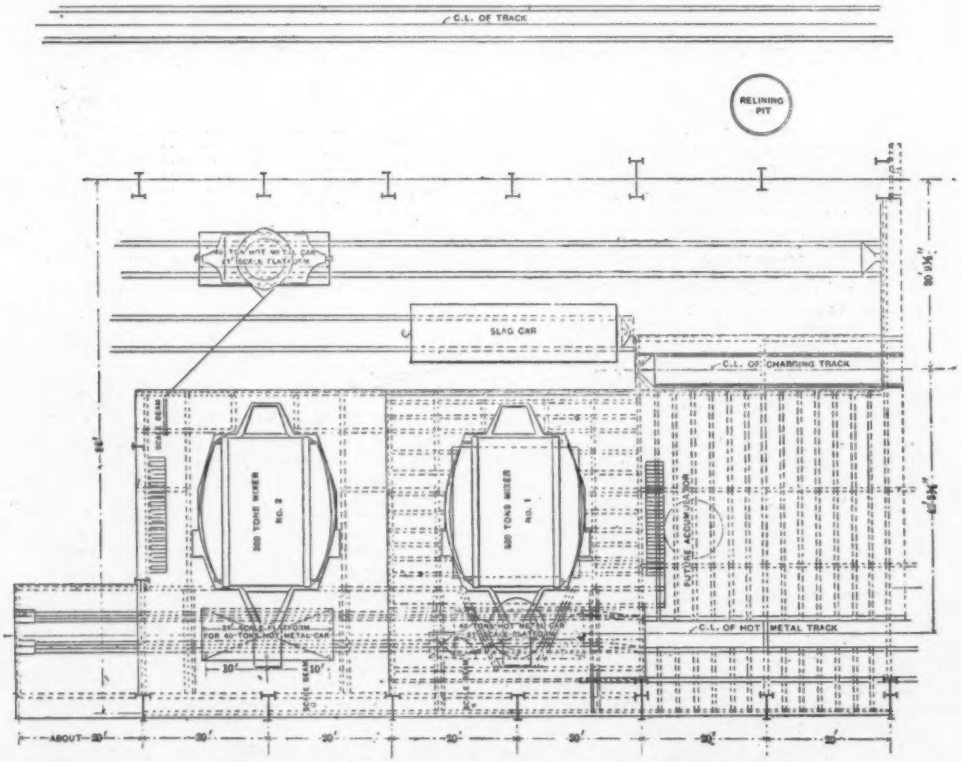


FIG. 4.—PLAN SHOWING GENERAL ARRANGEMENT OF MIXER BUILDING.

Of the six basic open-hearth buildings with four-

teen furnaces each, provided for in the finished plans, Nos. 3 and 4 are completed, and foundations for No. 1 are in. No. 2 will be erected next, but

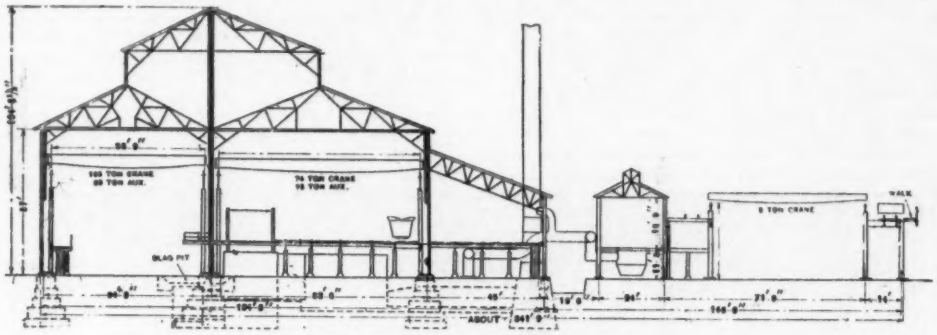


FIG. 2.—CROSS-SECTION OF OPEN-HEARTH PLANT.

the erection of Nos. 5 and 6 will depend upon future requirements; space, however, has been reserved for them.

All the open-hearth buildings are identical in construction and uniform in size, being 1,189 ft. long by 193 ft. wide, with a height of 67 ft. above the ground floor. They are divided into two main spans of 83 ft. and 65 ft., occupied by the charging floor and tapping and pouring tracks, respectively, with a lean-to of 45 ft. on the side containing three tracks for stock storage. The buildings are grouped in pairs, with a scrap yard and skull cracker structure between each pair. Owing to the angular

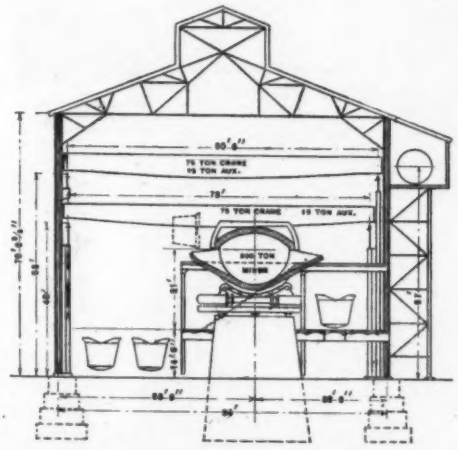


FIG. 3.—CROSS-SECTION OF MIXER BUILDING.

alignment of the houses one of each pair overlaps the other about half its length. In Fig. 1 is shown a portion of the plan of one of the open-hearth buildings, which is typical of the general arrangement. Fig. 2 is a cross section through the building.

Two 300-ton mixers are installed in a building 86 ft. by 120 ft. at the north end of each open-hearth building, entered by two tracks. Figs. 3 and 4 show the section and plan of the mixer building. The ladles of hot metal are hoisted from the trucks by a double trolley crane, having a main hoist of 75 tons capacity, with a 15-ton auxiliary for tipping and pouring into the mixers. The latter are of usual construction, rolling in a cradle frame to pour into the charging ladles on the opposite side. One of the two standard gauge tracks which run parallel with the furnaces extends along the opposite side of the steel charging floor into the mixer building, and metal is carried over it

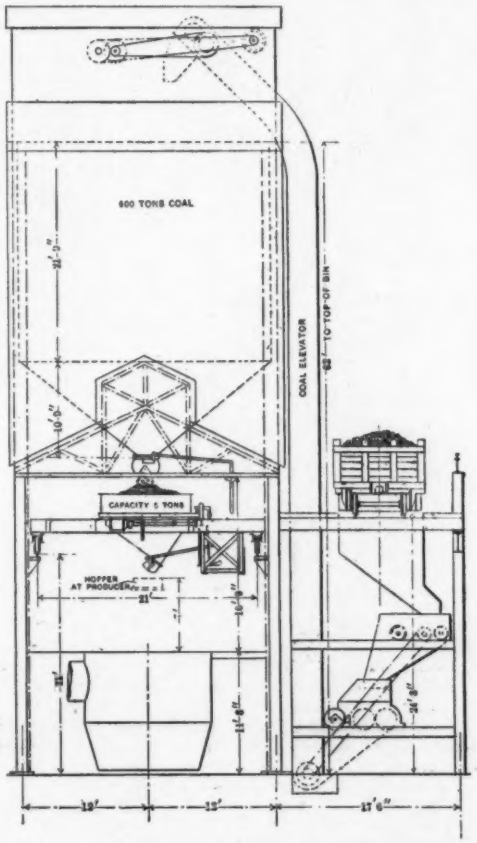


FIG. 6.—COAL HANDLING EQUIPMENT FOR THE GAS PRODUCERS.

from the mixers to a point opposite the particular furnace to be charged, in 60-ton ladles on an electrically-operated hot-metal car.

The open-hearth furnaces themselves, as will be seen from Fig. 5, are not materially different in design and construction from the generally approved type in modern basic open-hearth practice. They are substantially built and have a hearth area of 16 ft. by 36 ft. The combined chequer-work in the air and gas regenerative chambers on each side measures 5,057 cubic feet, or nearly 100 cubic feet per ton of metal in the hearth at a rated capacity of 60 tons. In the furnaces already built the doors are operated by hydraulic power; but in furtherance of the general plan to use electric motor-power appliances, wherever possible to do so advantageously, electrically-operated furnace door mechanism is under consideration for the future plants. A feature of

The Gas Producers.

Fuel is supplied to the open-hearth furnaces by a Morgan continuous gas producer plant, having one 10-ft. producer for each furnace. These are housed in a building 24 ft. wide, running the full length of the open-hearth building on the side next to the storage lean-to. The coal-handling apparatus installed in connection with the producers, Fig. 6, is very complete. It consists of an electrically driven coal crusher into which coal is dumped through a chute from cars on a trestle track, a double skip elevator, and four scale hopper cranes used for distributing crushed coal from a 600-ton overhead bin, which charge the coal directly into the producers. The movement of the skips is auto-

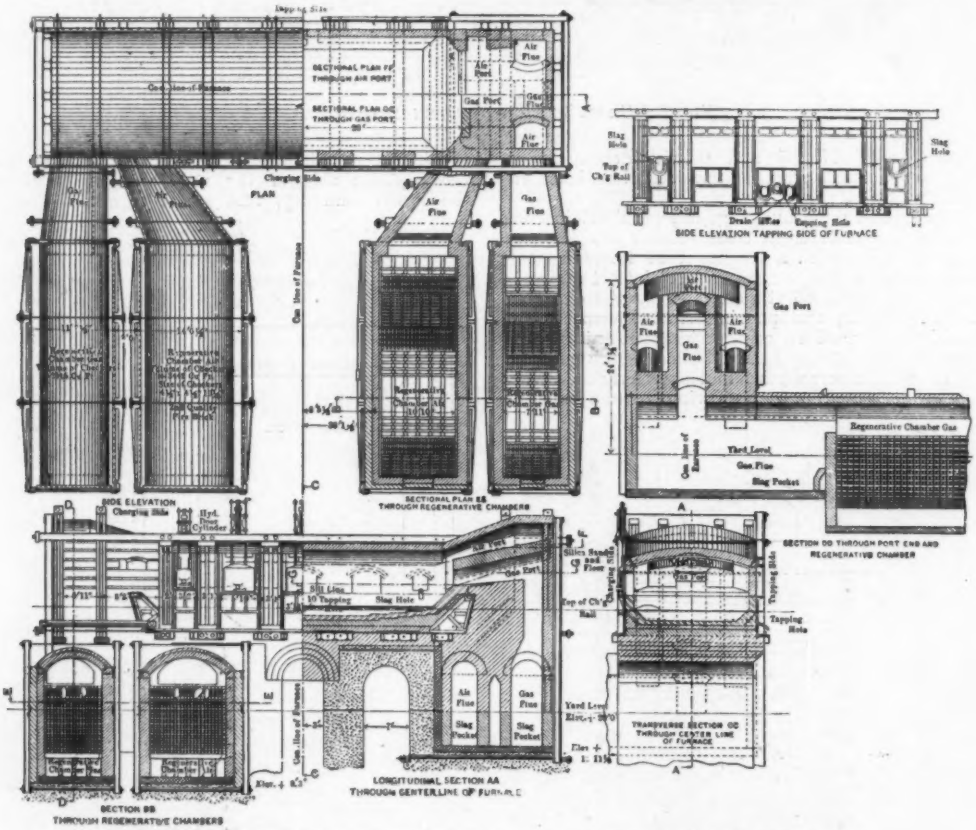

PLAN
SIDE ELEVATION TAPPING SIDE OF FURNACE
SECTION DD THROUGH PORT END AND REGENERATIVE CHAMBER
SIDE ELEVATION Charging Side
SECTIONAL PLAN EE THROUGH REGENERATIVE CHAMBERS
LONGITUDINAL SECTION AA THROUGH CENTERLINE OF FURNACE
TRANSVERSE SECTION CC THROUGH CENTER LINE OF FURNACE
SECTION BB THROUGH REGENERATIVE CHAMBERS

FIG. 5.—GENERAL DRAWING AND CROSS-SECTION OF THE OPEN-HEARTH FURNACES.

advantage in such a system would be the elimination of trouble arising from frozen water pipes in hydraulic installations.

In conjunction with the open-hearth furnaces are three stripper houses, Nos. 2 and 3 being already in service, while No. 1 has not yet been built. Nos. 2 and 3 are opposite and closely adjacent to the soaking pits of the rail mill and billet mill, respectively. One of these buildings is equipped with one, and the other with two, 200-ton electrically operated stripper cranes.

When the 56 open-hearth furnaces in the four buildings which comprise the immediate plans of construction are in operation, the plant will have a monthly capacity of 225,000 tons, or about 2,700,000 tons of steel per year.

matically controlled. As the car nears the limit of its downward travel it opens the coal bin door, and, in stopping, rests on a counterweighted lever. When the counterweight is overbalanced by the filling of the skip, it settles down about 3 in., thus actuating a switch which starts the car on its upward course, closing the coal bin door as it goes. This operation is repeated by the second skip, and continues without interruption until the coal bin is empty.

THE PARKER FOUNDRY COMPANY, LIMITED, of Derby, has been placed on the Admiralty list of firms eligible to tender for steel castings for machinery purposes and hull work of his Majesty's ships.

A Swedish Electric Furnace.

The results of the experiments in the electric smelting of iron ore that have now been carried on for two and a-half years at the Domnarfvet Works in Sweden, have recently been published, and have exceeded all expectations. The three Swedish engineers who have superintended the experiments are said to hold the opinion that the problem of smelting iron ore by means of electricity has now been solved, not only technically, but also commercially.

The cost of the experimental work has partly been paid by the Stora Kopparbergs Bergslags Aktiebolag and the Traffikaktiebolaget Grängesberg-Oxelösund. who have obtained the rights of using the patented process, the owners of which are the Aktiebolag Elektrometal, of Ludvika. Their representatives in Great Britain are Messrs. Jens Orten-Böving, 72, Victoria Street, Westminster.

The Aktiebolaget Elektrometal are proposing to erect in Norway what will be the first electric smelting plant in the world for the production of pig-iron on a commercial scale. The first installation will be built this summer, and will include two iron ore reduction furnaces of 2,500 h.p. each and two steel furnaces of 600 h.p. each. All furnaces will be operated with two-phase current. The plant will later be enlarged by erecting four more iron ore reduction furnaces of 2,500 h.p. each and four steel furnaces of larger size than 600 h.p.

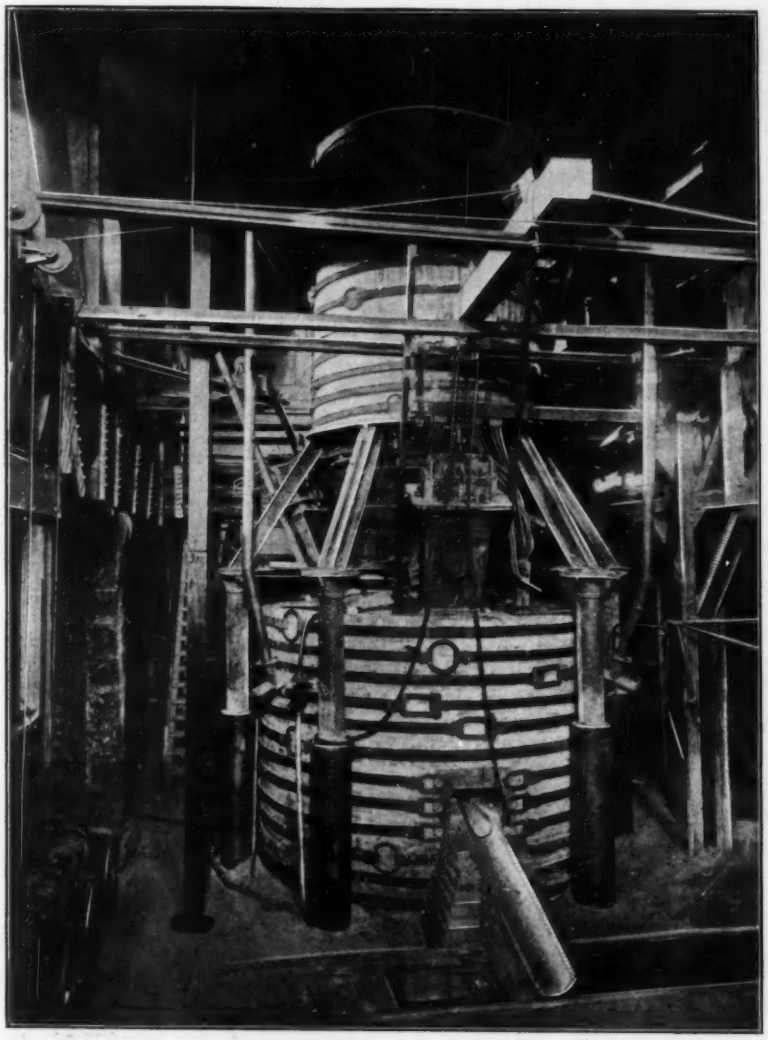


FIG. 1.—ELECTRIC FURNACE FOR SMELTING IRON ORE, BUILT BY THE AKTIEBOLAG ELEKTROMETAL, LUDVIKA, SWEDEN.

An installation of these furnaces has also been suggested for Canada, each furnace of a capacity of 2,500 h.p., with an annual production of between 11,000 and 12,000 tons of high-class metal. The pig-iron will be of charcoal quality.

It is right to state that it is due in a measure to the efforts of Mr. Louis Simpson, of Ottawa—who eight years ago asked the Government of Canada to send out to Europe a Royal Commission to investigate the electric furnaces at that time existing, the report of which Commission is known to the world as Dr. Haanel's Report on Electric Smelting—that the attention of the Canadians was directed to this very important advance in the iron industry.

By this process it is estimated that the yield of metal from the ore will be about 3½ to 4 tons per horse-power annum. The general construction of the furnace will be seen from the annexed illustration, Fig. 1, which represents one of the furnaces at the Domnarfvet Works.

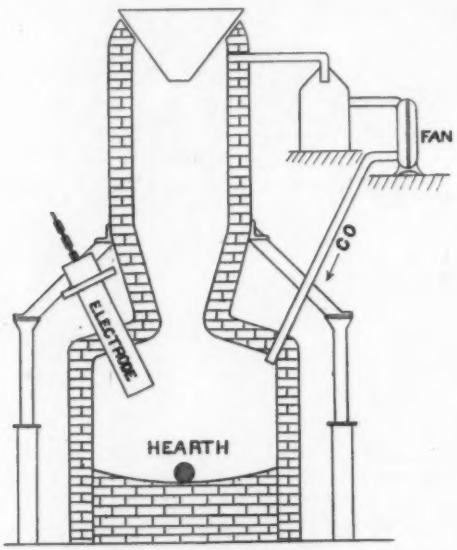


FIG. 2.—DIAGRAMMATIC SECTION OF ELECTRIC FURNACE SHOWN IN FIG. 1.

Dr. Haanel, of Canada, who has visited the plant in Sweden, recently returned home, and his report to the Canadian Government will be awaited with interest. Mr. Louis Simpson, to whom we are indebted for the data contained in this article, estimates the cost of producing pig-iron by the process in Canada, under favourable conditions, as follows:—

	Dols.
Ore (55 per cent. metallic iron) at 2.00 dols. per ton (1.8 ton)...	3.60
Charcoal 350 kg. at 6.00 dols. per ton...	2.10
Electric energy ½ H.P. at 20 dols. per E.H.P.-year	5.00
Limestone	0.20
Labour	0.80
Carbon electrodes 15 lbs. per ton pig-iron at 2 cents per lb....	0.30
General expenses	1.50
	13.50

From the diagrammatic outline of the furnace shown in Fig. 2, it will be seen that the hearth, in which are placed the electrodes, has built upon it a furnace shaft with bell hopper. The gas which rises up the shaft of the furnace, consisting largely of CO_2 is drawn off by a fan and forced into the hearth of the furnace around the electrodes.

A New Method of Treating Pig-iron.

"Vis" is the name applied to pig-iron treated by the patent process of Mr. Davies, Birmingham, which is being exploited by the "Vis" Patent Metal Company, whose offices are in Union Passage, Birmingham, and of which Company Mr. Davies is the managing director. The process consists of the addition of a special flux and certain proportions of other metals to the iron, and these additions can be made either into the ladle or cupola.

By the addition of the flux only to common pig-iron a clean, crisp casting, with a close grain, is claimed to be obtained, whilst the tensile strength is said to be from 20 per cent. to 30 per cent. above that of the same iron unfluxed, the crushing strain and elastic limit being equally satisfactory. The iron runs freely, and so is capable of taking a very fine impression when casting. It is claimed that hematite treated by the same process materially improves in quality; the skin of the iron can be made soft so that it can be easily drilled or machined, or it may be made so hard that tooling of any description is impossible. It is said to be uniform throughout, and when properly manipulated, free from blow-holes.

An unique metal is produced by the addition of copper and flux to an ordinary pig-iron. By this treatment it is possible to make a casting with an iron centre and a copper facing all over it, or the copper can, when desired, be cast on one side only; such facing of copper may be any thickness from ½ in. to 2 in. or 3 in. Of course, it is common knowledge that with copper electrically deposited upon cast iron the dirt contained in the iron finds its way on to the face and so spoils the uniformity of the article treated. It is claimed that with this new treatment the copper unites with the iron in such a manner that no dirt can get through.

It is, however, by the addition of nickel and flux to ordinary pig-iron that, at any rate from a commercial point of view, the most useful metal has been obtained. With this mixture castings can be made in the open sand, without any subsequent treatment, possessing a high degree of malleability. We were shown a ring which had been cast in sand, and which was bent oval in our presence without fracture. The fact that the melting point of the mixture is considerably higher than cast iron will add to its value for many industrial purposes if subsequent events justify its apparent possibilities. It should have a wide field of usefulness in connection with shipbuilding, as it is non-magnetic, close in grain, and takes a very high polish, in appearance almost equal to nickel; it corrodes slightly, but the corrosion is said to be easily wiped off. The metal possesses a great affinity for nickel, and will not blister or peel off, as is frequently the case with nickelling on ordinary iron or steel; and, further, when the nickel has worn off, the metal shows a foundation of the same colour. The makers state that the metal can be made from the softest possible up to that of hardened steel, without further treatment after leaving the mould.

It is claimed also that the peculiar properties imparted to the metal by the flux are not lost by remelting, the makers stating that it has been remelted up to twenty times, and that the results of the last melt are equal to the initial cast. The price of the new metal is, needless to say, somewhat in excess of ordinary malleable castings, but presuming always that its properties are constant on remelting, the value of the scrap would, of course, be all in its favour, so that the ultimate difference between the two would prove very slight, and probably result in favour of the new metal.

Patterns and Pattern-makers' Timber.

By A. Napier.

The casting of metals involves the use of patterns of many different materials and of many different styles, but in the great majority of cases wood is the material used. Other materials partake more of the nature of specialities. It is these patterns made out of wood that the writer proposes to consider, with the object of placing before pattern-makers several points which may be useful in assisting them in the selection of timber for specific purposes. All workers in wood have a more or less large knowledge of a variety of woods, but there are many who might profit by a general summary of the qualities of different woods.

Styles of Pattern.

Of all the styles of moulding that are in every-day practice loam moulding makes the least demand on the timber merchant. In constructing a pattern in loam it is not advisable to use wood more than sparingly, for its use involves several difficulties. In the first place provision must be made for the swelling of the wood, which absorbs a good deal of moisture from the loam. Strickles or sweeps, the outlines of which conform to the shape of the mould, and which work on a spindle or travel along guides, often comprise the whole of the pattern. With these patterns the best timber to use is one which is not expensive and which is not very absorbent, but is hard in texture. The property of being easily worked, which is a great feature with other classes of patterns, is not of importance here.

Green sand moulding requires patterns of quite a different nature, as also does dry sand moulding, as regards construction, these being simply models of the objects to be cast, divided into a suitable number of parts or in a whole complete model. It is in the manufacture of these patterns that the importance of the wood used is so great. The writer proposes, after classifving broadly the different patterns used, to consider the properties and qualities of the various woods available for use in the pattern-shop.

When designing and constructing a pattern there are very many points to consider with a view to economy. In the first place, it is necessary to ascertain to what extent the pattern will be used, for, obviously, a pattern that has only to serve for one lot of, say, 50 castings, will not justify the labour and class of material that would be employed for a pattern to be kept in stock for use in connection with many repeat orders.

It is often very difficult to know just to what extent to apply this rule, for an order may be given for castings that appear to be a standard thing, but the design may suddenly be superseded by a better one and the pattern will then be of no further use. On the other hand, repeat orders to a considerable extent may be received for a most unlikely casting. It, therefore, rests with the foreman pattern-maker to decide whether the pattern justifies the best material and a good deal of labour, or whether a pattern that will just serve the immediate purpose is best. With the best of judgment in this matter, however, the wisest course cannot be always selected.

Patterns Classified.

According to the use to which a pattern is to be put so must it be constructed. This also, to a great extent, governs the choice of the material to be used. Patterns may be broadly divided into three classes:—(1) Those of a temporary character, and which are not likely to be used for repeat orders; (2) those patterns that are likely to be used occasionally and at long intervals, and for this reason have to be preserved; and (3) the patterns which are used frequently and are regarded as standard. Each of these patterns need to be treated differently as regards the labour spent on them and the wood used.

The first class of patterns should be as simple and cheap in production as is compatible with a due fulfilment of their duties, and they should not be kept, as they only lumber the pattern store room and serve no purpose. The question of which wood to use for their construction is not important so long as it is cheap; any wood is good enough if it will stand the immediate usage and produce a good mould. The question of shrinkage and such like during storage is left out of the question.

The second class of patterns must be made with more regard both as to the construction and the wood employed, for they have to stand rough usage in the foundry, and what is more important, the trouble of twisting and warping in storage. The timber, then, must be chosen with due regard to these features, and the pattern then becomes more costly.

The third class of patterns, since they have to be continually used and are thus standing a lot of rough handling, cannot be made too hard and strong. They are the most expensive, as they must be made of the best and hardest material to withstand shrinkage and twisting tendencies and damage by being roughly handled. The wood should, by preference, be some hard wood, such as mahogany or cherry, and the dowel pins should be of metal, for while wooden pins serve the purpose very well for ordinary patterns, after repeated use the dowels may become damp and swell. They will then fit badly and have to be eased, and this, after a few times, results in a bad joint.

After it has been decided by the foreman pattern-maker whether the pattern is of class 1, 2, or 3, he must choose his wood to suit, and this will, of course, be governed to some extent by the timber available and the price. In order to choose to the best advantage he should know a good deal about the qualities of different woods, and in view of this the writer will now consider the different woods which a pattern-maker has available for his use.

Different Woods for Patterns.

Pine is perhaps the most commonly used wood of any importance employed by pattern-makers. The term pine, however, covers so many different species of wood that a distinction must be made. Pine is botanically divided into a great number of varieties—over a couple of hundred in all—but only a very few even get on the market for ordinary use.

Scotch fir, or red fir (*Pinus silvestris*), or "deal," as it is often termed, must not be confused with Weymouth pine or yellow pine (*Pinus strobus*), or, as it is called in the United States, white pine. This latter is the pattern-maker's timber, and is found in its best quality in the neighbourhood of the Great Lakes of North America. Scotch fir may be used at times for patterns of a large character, but it is really best as a builder's wood. The North American yellow

pine referred to is light, soft and straight-grained, and of uniform colour and texture. The colour is a yellow of a shade between ordinary red wood and white wood. The wood will stand vibration, is very easily worked, and is also remarkably free from knots and warping in the better qualities. The shrinkage across the grain is well understood, and it has been claimed that it will also shrink lengthwise, but if this is the case such shrinkage is not much. Its resistance to pressure is low, and so it will not stand a deal of rough usage. The supplies of this timber are rapidly being used up, for it is a slow-growing timber, taking from 150 to 200 years.

Red pine (*Pinus resinosa*) is a native of Canada and the States. The tree yields timber of a clean but rather knotty nature, of a rather straw colour, tough, elastic, fairly strong and fine-grain. It works up with a silky texture, and is in many ways an excellent timber, though from the pattern-maker's point of view it has several drawbacks for good work, amongst these being the trouble with knots. It is often used for large patterns, but is poor economy for small work.

Another soft wood which is useful is cedar. It is not strong enough for constructive purposes, but it is light, soft, has a fine texture, and is of a dull greyish-brown or red colour. There is also a Havana wood or bastard Barbardos cedar of reddish-brown colour, similar to mahogany, but much softer, which is to some extent a suitable wood. Cedar is shipped from St. Domingo, Honduras, Tabasco, and other ports in Mexico. Its value is lower than mahogany from the same ports. Pencil cedar is distinct, being a small wood with a decayed centre.

There are numerous other soft woods belonging chiefly to the pine varieties, which are more or less suitable for the larger and rougher patterns, but as their use is confined to such work, and as they should never be employed for finer and more important patterns, their qualities and properties do not call for special description.

Coming now to the hard woods, we will first take mahogany. There are several species of mahogany, the most important being known botanically as *Mahogoni Swietenia*, *Soymeda febrifuga*, *Chloroxylon*, and *Khaya Senegalensis*. The first is the mahogany commonly known in this country and is found in America between latitudes of 10 degrees and 23 degrees north of the Equator. The second variety, or East Indian mahogany, lacks the bright warm colour of the first variety. The third is found chiefly in Bengal, and is similar to the others, but not so large and of a colour similar to boxwood. The fourth is an African mahogany.

The first, or American, variety is often found with trunks 50 ft. or 60 ft. long, and 7 ft. to 8 ft. in diameter. The wood does not contain turpentine or other inflammable matter, and is difficult to ignite, which features are all valuable from the pattern-maker's standpoint. The style of the grain is the great question of importance; good quality consists in close grain and fine texture, which gives a wood fine and free in working. A bad piece of timber would have a coarse, harsh and brittle grain. The colour varies from very light, approaching birch in shade, to a deep red, and the writer has seen some mahogany so light in colour that when placed a yard or two away it has been mistaken for a reddish piece of yellow pine. The mahogany from the American districts is practically all the same from a botanical point of view, though it is shipped from many places. The standard imports to England come from St. Domingo and Cuba (which rank as Spanish mahogany), and from Honduras and Tabasco (which rank as baywood). The former class takes its name from the ports, for there is no real Spanish mahogany. The important characteristic of Spanish mahogany is texture and not "figure," and the wood mellows with age, though that shipped from the mainland of Central America and Africa tends rather to fade with age. Spanish mahogany has a silky texture and fine grain, with little white specks, while baywood has usually black specks in the grain. The latter is generally imported in larger sizes than the Spanish mahogany, and compares favourably with regard to texture and economy in conversion. When buying this wood it is necessary to be very careful in selecting, as other shipments are often classed with it without discrimination.

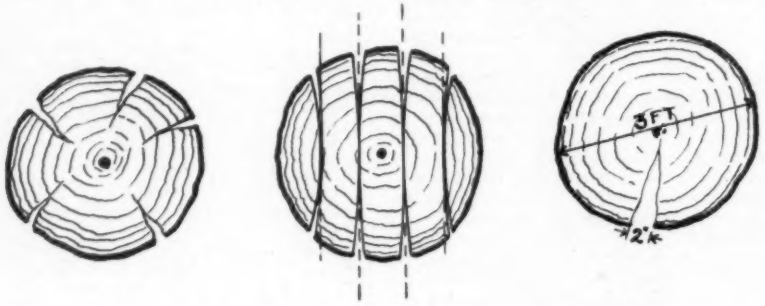


FIG. 1. FIG. 2. FIG. 3.

ILLUSTRATING THE SHRINKAGE OF WOODS.

African mahogany is the largest variety. It is largely imported, but as shipments vary considerably, care is needed in selecting it. The lower grades fetch moderate prices. The colour varies from nearly white, which characterises a soft wood, to blood-red, which characterises a hard wood.

There is also the white mahogany (*Chloroxylon*), which is sometimes shipped to England, but it does not compare with the other varieties named. It is harder to work, and so, though it fetches lower prices, it is not such a desirable wood for use in patterns.

Teak is another wood that is to be recommended for some purposes, for it is hard and non-resinous. It comes chiefly from India, Burmah and Siam. It contains an essential oil which prevents rotting under exposure and alternations of heat and wet, and iron in contact with it does not corrode it. Teak is usually straight-grained, does not warp, twist or split, and has a shrinkage of $\frac{1}{8}$ in. in a 20-in. width. It is imported sawn, and is generally square and clear of sap. The demand on account of its very good qualities is high, and so is the price.

Chestnut (common Spanish or small sweet chestnut) grows to a great size, and frequently has a diameter of 3 ft., and a height of 40 ft. It is somewhat like oak in appearance, but the medullary rays are not so pronounced. It stands well for most purposes, and

finds considerable employment. American chestnut is easily worked and fairly durable, but is not really a desirable wood, as it is subject to ring shakes and a coarse texture. Horse chestnut ranks as a poor wood, for it is soft and has no great strength or durability. The colour is white.

Pear tree yields a heavy wood which is strong and extremely fine in grain. The shrinkage of this is, however, great, but it is very useful for many purposes, particularly for small work.

Cherry wood finds great popularity in the States for patterns that have to stand wear, and has many admirable qualities; but it is not imported into England to any great extent. Its use is often advocated in American foundry text-books and journals, but in the English foundry it is rather a rarity.

Maple is often employed for patterns that are standard, and have to put up with rough usage. The variety known as hard maple is a fine-grained wood and works cleanly. It is popular in America, and grows plentifully in that country in the Northern States and Canada. It is heavy, hard, strong and tough, and does not splinter. Silver maple gives a lighter and softer wood, but for most purposes is inferior to hard maple. Curled maple and bird's eye maple are accidental forms, but not uncommon, and comprise a class of wood well known to the cabinet-maker; but since the value lies in the grain and colour such wood is not specially recommended to the pattern-maker. The sycamore, also known in the North of England and in Scotland as the plane-tree, is really a class of maple. The young tree gives a white wood, but as the tree gets older the wood becomes yellow, and when mature rather brown. This wood is an excellent one for purposes to which a hard wood must be put, and it does not splinter or shell with the grain under frequent washing.

Shrinkage and Warping.

In constructing patterns which have to retain their form correctly and be used many times, it is necessary to consider the tendency to warp one way which practically all timber possesses. This is owing to the structure of the fibre. The section of a tree is composed of a number of rings, called annular rings, each representing a year of the age of the tree. These rings are composed of very fine tubes or capillaries which convey the sap through the wood: when the wood becomes dry they contract in diameter and so the rings become smaller. This means that as the outside of the log dries first and so becomes smaller in diameter something must give way if the centre is too hard to be compressed. This results in the log "shaking," as shown in Fig. 1. The same inclination to warp in that direction is shown when the log is cut into boards, and the style of shrinkage is shown in Fig. 2, the illustrations being somewhat exaggerated. This warping varies with the class of timber. The writer has seen one example of a log section where a single split had resulted from the shrinkage; the diameter of the log was about 3 ft., and the split on the circumference measured over 2 in., as shown in Fig. 3. It is important when considering the construction of a pattern to bear this shrinkage and warping tendency in mind, so that the construction may counteract it as much as possible. There is another tendency which many woods show, and that is to twist in the length of the grain. This results from strain while the tree is growing, such as from the loss of a heavy branch at one side, or the prevalence of heavy winds in one direction. The drying out of the sap also contributes to this twisting or warping, and when important patterns are to be made the choice of the wood should be confined to those which have very little tendency to shrink or warp, as is the case with some of the woods previously named.

Finishing Patterns.

In order to give the patterns a clean finish and preserve them from dampness and its ill-effects, they are usually prepared in some way, such as by coating them with shellac dissolved in methylated spirits. This is a quick way of finishing and gives a smooth surface, and provides a certain amount of protection against the damp. But for patterns for loam work this protection is not sufficient, as the pattern has to remain in close contact with moisture for some time. Painting can then be employed for loam work patterns, but usually they are thoroughly oiled, and this is perhaps the better method.

British Foundrymen's Association.

Lancashire Branch.

On Saturday, April 17, about thirty-five members of the Lancashire Branch journeyed to Bolton to visit the works of Messrs. J. Musgrave & Sons, Limited, Globe Iron Works. On arrival at the works the party divided into three sections, and were conducted through the various departments, visiting the pattern shops, foundries, machine, fitting, and erecting shops. The various stages of manufacture of some large turbines which the firm have now under construction proved of special interest, the loam moulds of some of the casings being seen in the foundry while the completion of the internal parts was in progress in the machine and fitting shops. Various types of the firm's well-known specialities in large steam engines, superheaters, etc., were seen in various stages, and a most enjoyable and instructive afternoon was spent.

Later in the afternoon the members adjourned to Talbot's Restaurant, where tea was provided by the kindness of Mr. Frank E. Musgrave, managing director of the firm. After tea short speeches were made, and a hearty vote of thanks accorded to Messrs. Musgrave for their kindness in allowing the visit. The proceedings terminated with a vote of thanks to the heads of departments who had devoted their afternoon to showing the members over the works.

Birmingham Branch.

The concluding lecture of the Session in connection with the Birmingham Branch of the British Foundrymen's Association was given on Saturday, April 24, at the Technical School, by Mr. J. M. Stansbie, the subject being "The Electric Furnace." Mr. Mason (Vice-President) presided in the absence of the President of the Branch, Mr. R. Buchanan.

The lecturer pointed out that falling water, burning gas, and burning coal were the three great sources of energy, but the modern way was to convert mechanical energy into electrical energy, which, in turn, was reconverted into heat. By means of a series of slides the lecturer illustrated the various forms of machine for the production of electrical energy. The electric alternator was the one most largely used for metallurgical purposes. At present, electrical energy was too expensive for practical purposes in Birmingham, and, roughly speaking, would cost about 1s. 8d. to melt a hundredweight of cast iron, which was a prohibitive price. The great advantage of electricity was that the heat was developed right in the centre of the material they wished to melt, because the material placed between the carbons, to offer resistance, generated central heat. Views of the Héroult, Rodenhauser, and other furnaces were given. The lecturer then proceeded to show the melting powers of electricity in a couple of miniature furnaces by melting some large nails at a temperature of about 2,000 degrees. The demonstration was completely success.

ful, the molten iron being poured out in a very few minutes. In replying to some questions which followed, Mr. Stansbie said the electric furnace had proved enormously useful for dealing with certain alloys, especially of the ferro-silicon type, partly because a higher temperature had been realised than was possible with the ordinary furnace, and also because greater purity was secured in the absence of various fuels, such as coal and coke, which gave off impurities. Certain special steels could now be made which were quite impossible a few years ago, and there was certainly a great future before the electric furnaces in dealing with ferro-chromium, vanadium, ferro-tungsten, and similar metals. The speaker strongly invited the members to attend a series of lectures arranged during the summer on "The Generation of Heat," of which some would be devoted to the electrical furnace. On the question of cost, he said that a new era had been opened up for the electric furnace through the turning to account of blast-furnace gases. It was found extremely useful in Sheffield at the establishment of Messrs. Vickers, but the most important local enterprise of the kind was one in operation at Ocker Hill. It was possible to regulate the composition of the metal with the greatest possible exactness, and he thought the Kjellin furnace was the furnace of the future. It was likely also that the Héroult furnace would become sufficiently economical as producer gas became cheaper. Probably the scarcity of water-power in the country was the main reason why we were behind the Continent in the use of electric furnaces.

A hearty vote of thanks was accorded the lecturer, and the Chairman, on behalf of the Metallurgical Society, invited the meeting to attend Professor Carpenter's lecture on "The Hardening of Steel."

Correspondence.

Use of the Core Machine in the Foundry.

SIR,—I am convinced that the value and utility of the core machine, particularly the horizontal type with the worm, are by no means fully appreciated, for several foremen with whom I have conversed who have had them in use in their shops declare unfavourably against them. These may be taken as typical of others. Then there are that greater number who only know of the machine by report. In view of this hostile or neutral position taken up by the many may the statement of a favourable minority (even though it be but a monetarily disinterested minority of one), be put forward.

At the outset, I may say that we make more cores in a day than do the bulk of foundries in a month, and we are the only large firm in a district where there are several large foundries, who have a core-making machine in use. We use between five and six hundred round cores in a day, varying in diameter from ⅜ in. to 2¼ in., and in length from 2 to 14 in., so that it will be seen that my favourable opinion is one based upon no small experience. The cores are made from a mixture of nine parts of sharp sand, one of flour, and quarter oil. Some readers may smile at this mixture, but after trying numerous others I find that it gives the best results. The cores drop out of the castings with just a slight rap, thus saving much labour in the dressing department. Anyone connected with foundry work will know the difficulty experienced in getting out long, thin cores.

The cores cannot be handled when green, but when baked are very hard. Wiring, except in very rare instances, is rendered superfluous. Some of the moulds cast have the core lying in a horizontal position with an inch thickness of metal all round them, the core being 9 in. long and ¾ in. diameter. The advantages gained are:—A more accurate core; wiring dispensed with: fewer blown castings: the saving of labour in the dressing shop through the mixture of the sand; and last, but not least, the saving in labour in making, for a young boy can do the core-making hitherto performed by men.

Here I would like to state a few reasons why, in my opinion, the core machine is not in more extensive use. I think that some of the firms manufacturing these machines might do better if they would send out men with them who had a little more knowledge of their work, and also if they would be careful what they send. For instance, the firm who supplied us sent with the machine some very thin sheet-iron plates to receive the cores when pushed out of the machine. The plates were 2 ft. in length and 7 in. in width, recessed to carry about eight lengths of cores. When the man who accompanied the machine began to work it, the cores all broke, the plates being so crooked. I measured the cores and found they were fully one-sixteenth bigger in diameter in different parts of the core, so I had made some cast-iron plates with the recess worked in by the planing machine; these we used for patterns. The plates we now produce cheaply, and are a great improvement upon those sent by the firm.

Another thing I found was likely to prove costly was the rapid wearing out of worms through the great number of cores made. I, however, discovered a method of producing our own, and that so economically that the cost is hardly worth the mentioning.

Yours, etc.,

"FOREMAN MOULDER."

Replies.

A Book on Foundry Work.

We have received from one of our readers a request for advice in selecting a book on foundry work. The applicant is a working moulder inspired with a desire to rise, and accordingly he turns to books for aid in extending his knowledge. It is, however, extremely difficult to select any one book and say that it will give the most aid on foundry work. There are several excellent works by different authors published, and each, to some extent, represents practical experience in the foundry; but all of these are sure to touch on many points that do not require elucidation to the average moulder. To commence with, we may rule out of consideration all the small handbooks that are designed for the elementary class student, for the working moulder does not need initiating into the preliminaries of his calling. All the useful information in these smaller books is also found in the more extensive works, and it is to the latter we then turn. Among the best standard books dealing with foundry practice may be mentioned the following:—

(1) "Modern Foundry Practice." By John Sharp. Messrs. E. & F. Spon, Limited, Haymarket, W.C.

(2) "American Foundry Practice," and

(3) "The Moulder's Text-book." By Thos. D. West. Messrs. Chapman & Hall, Limited.

(4) "General Foundry Practice." By Prof. Andrew McWilliam & Percy Longmuir. Messrs. Charles Griffin & Company, Limited, Exeter Street, Strand.

These are all very good books, each with its own particular merits. The first is well known as a comprehensive work, for it deals with the characteristics of iron, moulding, the materials used, and descriptions of the machinery and appliances employed in foundry work. The second and third books, by Mr. West, are uniform volumes, the one dealing with foundry prac-

tice in general, and the other with moulding in all its phases. The fourth book on the list gives a condensed and crystallised account of the science and practice of iron, steel and brass founding, and all the departments of foundry work are dealt with in a comprehensive and practical way. It was designed for foundry managers and foremen, and since it deals essentially with English foundry practice, it would be, perhaps, the best suited to the needs of our reader, though we by no means wish to discount the value of the other works mentioned. At the same time it must not be supposed that any one book on foundry practice will contain all that a prospective foreman needs to know. The metallurgy of cast iron, for instance, is really too big a subject to receive more than an outline of treatment in a book dealing with general foundry practice, and needs to be studied from more specialised treatises. Among those to select from are the following:—

(5) "The Metallurgy of Iron." By Prof. Thos. Turner. Messrs. Charles Griffin & Company, Limited.

(6) "Cast Iron." By W. J. Keep. Messrs. Chapman & Hall, Limited.

(7) "The Metallurgy of Iron and Steel." By A. Humboldt Sexton. The Scientific Publishing Company, Manchester.

(8) "The Metallurgy of Cast Iron." By Thos. D. West. The Cleveland Printing Company, Cleveland, Ohio, U.S.A.

If the student could also get hold of "An Introduction to the Study of Metallurgy," by the late Prof. Sir W. Roberts-Austin, he would be well repaid by a study of it. It must be remembered that an educational course, to be of the greatest utility, should embrace not only the study of foundry practice from books but the application in the course of the daily work of the instruction received. Also, the scientific side of iron founding must be studied, and for this end considerable attention must be given to at least elementary chemistry, in order that the higher works on metallurgy may be thoroughly appreciated. Association with other workers, either at technical associations' meetings or in private life is of great assistance to the aspirant for foundry honours, for his attention is often thus directed to questions and problems that otherwise he might not encounter until he lands in the same difficulties himself. There is a vast fund of information being afforded by writers in the various technical papers, which is seldom to be found in any book, and to qualify for a higher position one must keep thoroughly in touch with all the advances, scientific and mechanical, that are occurring day by day. It will be seen that a systematic attempt at self-education is by no means a simple matter, but the difficulties are not such as need deter any man with a fair amount of resolve and intelligence.

THE EDITOR.

Defects in Cast-Iron Moulds.

In reply to "J. R. S." I think that if the moulds with which he is experiencing defects were run, as

shown herewith, and hot metal used, there should be no trouble.

"S. W."

In reply to "J. R. S.," if he runs his casting from the end, with a gate at each side, so that the metal fills both sides simultaneously and meets at the top, he will probably overcome the difficulty. In the method he is using the metal has to creep over the top of the core in order to fill the other side. There is not sufficient pressure of metal to force the gases through the sand, and so they boil up through the metal, causing it to scab.

"C B."

Queries.

Iron Mixture for Chilled Plough Shares.

Can you give me any information as to how to secure the correct mixture of iron for obtaining a satisfactory chill in plough shares?

"W. J."

The "F.T.J." Bookshelf.

Strength of Materials.

By Arthur Morley, M.Sc., M.I.Mech.E. London: Longmans, Green & Company.

While it has been written mainly for engineering students, and covers the necessary ground for University and similar examinations on the subject, this book will also be useful to the practical engineer who is interested in the theory of the strength of materials. The work in many respects follows well-established lines, but there are several features dealt with that have formerly received very little attention in this class of text-book. Amongst these may be mentioned the strength of rotating discs and cylinders, the bending of curved bars, the strength of unstayed flat plates, and the stresses and instability arising from certain speeds of running machinery. Elastic stress and strain forms the subject of the opening chapter followed by the mechanical properties of metals, and then in turn are considered resilience and fluctuating stress, the theory of bending, stresses in beams and deflection of beams, direct and bending stresses, torsion, etc. A quantity of research work bearing upon the strength of materials has been drawn upon for examples and information, and most of the results have been presented in mathematical detail. This feature should prove of considerable aid to readers who have a practical knowledge of the subject and wish to follow the theoretical details fully. The final three chapters of the book are devoted to testing machines, apparatus and methods, special tests, and special materials. Numerous examples of typical testing machines are illustrated, as also are the forms of test pieces for various tests. In the chapter on special tests, the author describes several machines for repeated and reversed stresses, hardness, and other tests. The chapter on special materials deals with cement, concrete, stone, timber, wire ropes, etc., and, in conclusion, are tables of logarithms and other mathematical tables. The work stands as an excellent addition to the list of students' books on materials and tests, and its various features will be well appreciated.

ALLEY & MACLELLAN, LIMITED, Sentinel Works, Polmadie, Glasgow. From this firm we have received a copy of their catalogue No. 10, designed for the use of users of compressed air. It contains voluminous particulars with illustrations of the firm's air compressors, together with a variety of information useful to users. The catalogue, which extends to 150 odd pages, has been compiled with considerable care, and its arrangement is eminently convenient for ready reference.

Inventions.

Applications for Patents.

—o—

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

—o—

1909.

6,772. Automatic control of combustion in furnaces. F. H. Brown, 100, Wellington Street, Glasgow.
6,820.*Electric furnaces. J. H. Reid.
6,968. Machining metal structures or castings. Hulse & Company, Limited, E. Adams, and T. M. Lowthian.
6,993. Magnesium castings. (Chemische Fabrik Griesheim Elektron, Germany.)
7,034. Timing apparatus for controlling the supply of air to furnaces. E. C. Mills, 40, Victoria Buildings, Manchester.
7,036. Tuyeres of furnaces. J. McMillan, 100, Wellington Street, Glasgow.
7,155.*Machinery for making cores for foundry purposes. F. Penlington, 3, Brown Street, Market Street, Manchester.
7,269. Process for jointing or soldering aluminium. A. Jones, 6, Bank Street, Manchester.
7,353. Manufacture or casting of iron, steel, etc. J. E. Bennett, 4, Corporation Street, Manchester.
7,396.*Electrical induction furnaces. C. Grunwald.
7,549. Regenerative gas-heated cementation furnace, annealing furnace, etc. W. Kirkham, Wood Street, Sheffield.
7,893. Device for metal moulding. E. Kury, 27, Cecil Road, Erdington, Birmingham.
7,948. Annealing furnace. H. Baber.
8,100. Process for alloying iron with copper. E. E. Farmer and C. K. Graham, 24, Coleman Street, London.
8,194.*Electric induction furnaces. The Grondal Kjellin Company, Limited, and J. Härden.
8,299.*Furnaces. S. Dewhirst.
8,349.*Welded wrought-iron cylinder for heating metals. E. T. Lammine.
8,457. Crucible furnaces. P. J. Mallmann.
8,690. Making moulds for grooved pulley wheels, etc. C. Harris, Yewstock Cottage, Hardenhuish, Chippenham.
8,800. Furnaces for steam and other purposes. E. C. Mills, 40, Victoria Buildings, Manchester.
8,812. Furnace firebars. E. T. Wallis, 306, High Holborn, London.
8,894. Combined baffle-heater and circulator applicable to furnace fronts. A. Stewart.
8,903. Crucible furnaces and crucibles. J. Newton and C. Billington, Station Street, Longport, Staffs.
8,943.*Furnaces. U. Wedge, Clun House, Surrey Street, Strand, London.
8,983.*Apparatus for casting metal plates, especially tubular stereotype plates. (Duplex Printing Press Company, United States.)
9,015. Regenerator gas fire. H. W. Woodall and P. G. G. Moon, "Hill Croft," Alexandra Road, Upper Parkstone, Dorset.

Abstracts of British Patent Specifications recently accepted.

—o—

20,192 (1908). *Foundry Moulding Machines.* R. Geiger, of Friedrichshöhe, Reutlingen, Württemberg.—This invention relates to machines driven by means of a rotary motor, and employed to drive oppositely-handed side screws for operating the moving parts. Fig. 1 is a front elevation, and Fig. 2 a vertical side elevation, partially in section, of a moulding machine in which the pattern carrying table is rotatably mounted. The machine consists of two side frames *a* joined by a cross beam *b*, which carries a bracket *c* for supporting the motor *d*. On the left-hand side standard there is fixed the maximum current cut-out *f*. The motor *d* drives the shaft *h* through the medium of a safety coupling *g*, which preferably consists of teeth which grip with security in one direction only. The spindle *h* is provided with two endless screws *i* engaging with the wheels *k* and k^1. These wheels are arranged with oppositely cut teeth, and the screws on the spindle are, of course, correspondingly arranged. The wheels are fixed to the screwed spindles *m* and m^1 which are also arranged as left and right-handed screws respectively. It will be seen therefore that when the motor is driven the wheels are driven in opposite directions,

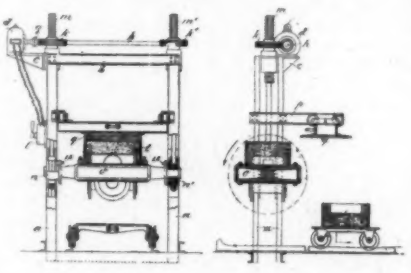


FIG. 1 FIG. 2

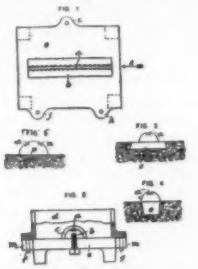
Geiger's Foundry Moulding Machine.

and, therefore, the spindles are also driven in opposite directions. In consequence of this arrangement no unbalanced end pressure is exerted on the driving shaft. The spindles are continued downwards and engage the cross heads *n* and n^1 which are guided in the standards. On these cross heads there is rotatably mounted the pattern carrier *o*. Holes are conveniently provided in the cross heads for receiving the pins *u* by which the rotatable pattern carrying table is held in the desired position so that either the top or bottom side of the table may be employed as desired. By means of the cross heads the pattern is moved upwards into the moulding box *t*, the upper end of which is adapted to fit over the counterpress plate *q*.

21,356 (1907). *Manufacture of Steel Alloys.* J. R. Crawford, late of Manhattan, Grange Road, Bushey, Herts, and now of Pasadena, Los Angeles County, California.—The invention relates to the introduction of an alloying metal or alloying metals into steel in such manner and in such proportion as will ensure in the combination the desired proportions of alloying metals with the minimum loss from oxidation or other causes and at the same time reduce or avoid the formation of blow-holes and such like imperfections. The inventor has discovered that by the introduction of the alloying metal in chemical combination with carbon, that is to say, as a carbide, or with nitrogen as a nitride, instead of as a simple ferro alloy, results of a highly satisfactory character are obtained. The carbide or nitride combination of the alloying metal may also be united with iron, previous to its introduction into the steel, forming a mixture of the carbide or nitride of the alloying metal with the iron. This latter method still further guards against loss during the process.

22,895 (1907). *"Chills" and Mode of Use in Making Chilled Metallic Castings.* J. Newton and C. Billington, Vulcan Works, Longport, Stoke-on-Trent.—This invention has reference to metallic chills, used for the purpose of quick cooling or chilling bronze or gun metal bearings and similar castings. In carrying the invention into practice, the inventors make such chills of any required shape and size, by casting a plate, or

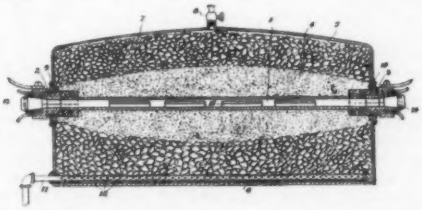
slab, in iron, with three or more legs or standards integral with their underside, one or more lugs, having a hole down through each, projecting from two of its sides, on a level, or nearly so, with its upper surface, and one or more projections (*b*) the required shape and size, integral with, or removably secured upon such top surface, conforming in shape to the inner or under surface of one half of a bearing, or bearings, or other metallic casting, or castings, each of such projections having one or more undercut longitudinal, straight grooves (*a*), at a suitable distance apart, in its top, or upper surface, in which a piece of string or wire may be laid, and afterwards, when the mould is hard, be withdrawn. Figure 1 is a plan view of a cast-iron plate or slab, with one projection integral on its upper



Newton & Billington's Chills for Making Chilled Metallic Castings.

surface, having a longitudinal undercut or dovetailed groove (*a*) in its top part. Figure 2 is an end elevation of Figure 1, looking as indicated by arrow at A, and showing a moulding box in part section in position, and the mode of securing projection or chill to cast-iron plates when not made integral with same. Figures 3 and 4 are an end elevation of a modification of Figures 1 and 2, and Figure 5 an end view of a "chill" or projection having two undercut or dovetailed longitudinal grooves in its upper surface, which may be cast integral with the top surface of a plate or slab, or be detachably secured thereto by one or more threaded metallic bolts or screws, or used in the manner shown.

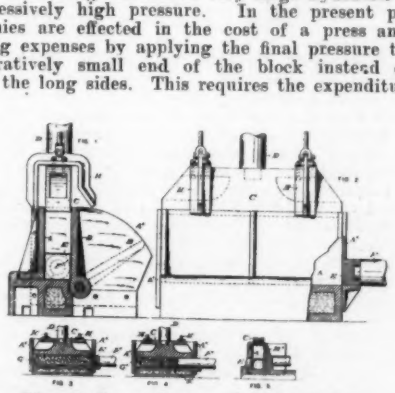
1,470 (1908). *Electric Furnaces.* The British Thomson-Houston Company, Limited, 83, Cannon Street, London, E.C.—It is the object of this invention to provide an electric furnace of the resistance tube type capable of use in heating refractory materials to exceedingly high tem-



Electric Furnace, by the British Thomson-Houston Company.

peratures, temperatures even as high as that at which carbon begins to vaporise, without danger that the material under treatment will be contaminated with carbon. To effect this result the inventors use as the resistance material of the furnace a refractory metal, either with or without the admixture of other suitable material. As a metal suitable for this purpose the refractory element tungsten has been proposed, and it has been suggested to protect an iron heating chamber from oxidation by surrounding it with a carbide as described in a prior Patent No. 27,755 of 1902. The resistance member of the furnace consists of a refractory metal tube 1 supported and supplied with current by copper terminals 2 and 3. These terminals are preferably water cooled, and are of sufficient mass to prevent destructive heating at the ends of the resistance tube 1. To protect the resistance tube 1 from oxidation it is surrounded or packed with some non-carbonaceous heat insulator 4 such as calcium oxide, alumina, thoria, magnesia, zirconia, etc. Further away from the resistance tube, outside of the very hot zone, carbonaceous material 5, such as coke may be used. The resistance tube and its refractory packings are all enclosed in a metal box 6 having a dome-shaped top 7 in which is a gas outlet 8. The water-cooled terminals of the resistance tube pass through the annular walls of the metal box 6, but are insulated therefrom by refractory bushings 9 and 10. Projecting into the metal box, near the bottom, is a metal tube 11 having perforations 12 through which hydrogen or other inert gas may be introduced. This gas can move upward through the box and out through the opening in the dome, and serves to prevent oxidation of the outside of the resistance tube 1. The inside of the tube can be similarly protected from oxidation by the passage of a stream of hydrogen or other inert gas through the tube. For most purposes, however, it is only necessary to close the ends of the tube with stoppers 13 and 14. Whatever oxygen enters the tube when the charge 15 is being introduced or removed is very quickly consumed, and is so small in quantity as not seriously to affect the resistance material.

8447 (1908). *Method of and Apparatus for Compressing Scrap Metal.* T. Sharp, of 30, Atkinson Road, Benwell, Newcastle-on-Tyne.—In the pressing of scrap iron and steel for subsequent heating and forging or rolling, it has long been customary to compress such scrap under hydraulic rams into rectangular blocks of suitable size, a convenient size for such a pressed block being two feet long and six inches square in transverse section. In the formation of such a block as previously carried out, the final pressure has always been applied to the block along one of its long sides, thus necessitating the use of very large hydraulic rams or excessively high pressure. In the present patent economies are effected in the cost of a press and its working expenses by applying the final pressure to the comparatively small end of the block instead of to one of the long sides. This requires the expenditure of

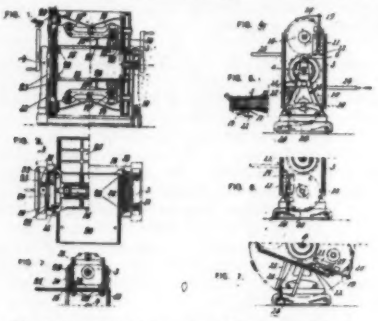


Sharp's Scrap Compressing Apparatus.

much less power to properly compress the block to the same extent as before, and the desired result may be attained by the use of two rams or pressing heads only. In a hydraulic press a ram may be used of six inches diameter under a pressure of one and a-half tons to the square inch, and still exert about the same final pressure per square inch upon the surface of the block upon which it is pressing as has before been exerted by the larger ram referred to upon the surface of the long side of the block, and consolidate the block to the same extent. Figure 1 illustrates such a press partly in end elevation, but chiefly in cross section. Figure 2 shows it in side elevation with a small part in longitudinal vertical section. Figures 3 and 4 are vertical longitudinal sections to a smaller scale showing in different positions the ram by means of which the final pressure is exerted upon a small end of a block.

Figure 6 is a cross section on a small scale of the improved press showing a somewhat modified form of a movable side to that shown in Figure 1.

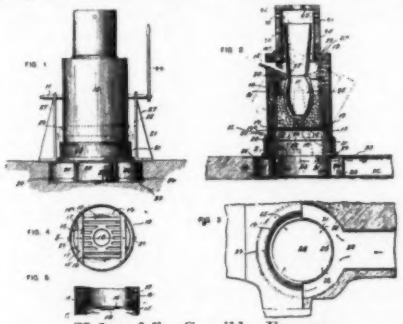
8,881 (1908). *Moulding Machine for Foundry Work.* G. A. Oertzen, 112, Lueg Allee, Düsseldorf, Ober Kassel, Germany.—This invention relates to a moulding machine with rotary frame and two moulding or pattern plates, which are movable in the frame, and are moved towards each other by means of cranks. A chief characteristic of the invention is that each of the two moulding plates, which are situated opposite one another in the frame, is extended in the direction of its length, so as to form a part which is without pattern, and serves as a pressing plate, and when moved apart and adjusted they enable the moulding box to be put on, filled, and removed, and when the particular parts are placed exactly one over the other, enable the pressing to be effected, and, if necessary, of each half of the moulding box separately. A further characteristic is that, by a single rotation of a driving wheel, the frame is rotated to the extent of 180 deg., and automatically fixed, and then, with continuous rotation, the pressing cranks are actuated and the pressing is effected. Figure 1 is a front elevation and partial vertical section. Figure 2 a plan and partial transverse section. Figure 3 a portion of a longitudinal section. Figure 4 a side



Moulding Machine for Foundry Work.

elevation. Figure 5 a portion of a transverse section. Figures 6 and 7 represent a longitudinal section of a portion of the machine specially illustrating a pawl mechanism in different positions. The rods 13 and 14 are adjustable so that the pressing beams which are moved against supports 33 of the rotary frame, can be adjusted according to the height of the moulding box. In the form of the invention illustrated these rods consist of the screw-threaded parts 13, 13^a, and 14, 14^a, with nuts 13^b or 14^b, by means of which the parts can be drawn together or extended. Each of the two nuts 13^b or 14^b can be connected with one another by a chain or in some other manner, so that they can be always moved together and uniformly. The moulding plates 25 and 26 are arranged between rollers 28, so that they can be easily adjusted. The roller bearings 32 are mounted on rods 29, Figure 3, on which springs 30 act so that the plates 25, 26 are always firmly pressed against the pressing beams 15, 16, and cannot shift automatically. In order, however, that the adjustment of the plates 25, 26, may be easily effected, when the pressing beams are moved apart, adjustable stops 31 are provided in the paths of the rods 29 which, when the pressing beams are moved apart, act on the rods to relieve the pressure of the roller bearings 32 on the pressing beams. After the pressing, the wheel 9 or 10, which is below at the time (in Figure 4, wheel 10), on continuing to rotate, comes with the slot 18 opposite the pin or pawl 17, which is provided on the rod 19, and runs through a slot in the frame 3, this pin or pawl catching in the slot 18, and so coupling the frame 3 and the wheel 10 together. The slot provided in the frame 3 for the passage of the pin 17 is, however, made oblong or oval, so that the frame is not at once carried along with the wheel 10, but only the pawl and the rod 19 carrying the same, which is raised out of the rest 24, the frame 3 being thus released, so that it participates in the rotation of the wheel 10 as a whole around the axis 4. Thus in each end position of the frame an upper moulding box part and a lower moulding box part can always be completed alternately.

12,342 (1908). *Crucible Furnaces.* W. J. Holzapfel, 409, Broadway, Scottdale, Pennsylvania, U.S.A.—The invention relates to that type of crucible furnaces in which the body is supported by the base and capable of being tilted to pour out the melted metal. Fig. 1 is a side elevation showing a preferred embodiment of the invention; Fig. 2 is a vertical sectional view; Fig. 3 is a horizontal sectional view on the line 3—3 of Fig. 2; Fig. 4 is a bottom plan view of the furnace casing showing the grate construction; and Fig. 5 is a detail sectional view on the line 5—5 of Fig. 4. Referring to the accompanying cuts, 10 designates an upright furnace casing having horizontal trunnions 11 projecting from its sides, and provided with an upper pouring lip 12, Figure 2. Within the furnace casing, and adjacent to the top a cover supporting flange 13 is provided, and adjacent to the bottom a grate base ring 14 is located. These two upper and lower rings are of substantially the same diameter and formed of fire-resisting material, and the intervening space between is provided with a lining *a* of fire bricks serving to protect the casing 10 from the heat. The grate construction of the present invention includes the transverse grate supporting bars 15, which are located beneath the grate base ring 14 at each side, and have their ends secured



Holzapfel's Crucible Furnace.

within the furnace casing as at 14. The main central grate 16 is supported by the transverse supporting bars 15, and extends across the opening of the base ring 14, and has its ends detachably secured thereto by means of screws 17. The centre of the grate is provided with a solid depressed portion 18, which forms a seat. A crucible 35, Fig. 2, preferably of graphite, is provided at the bottom with a supporting block 36, and is adapted to be seated within the furnace casing 10 upon the depressed central seat 18 of the main grate 16. The crucible is provided with an upper pouring lip 37, and is held in the casing in a position so that its pouring lip will register with the pouring lip 12 of the furnace casing. A top ring 39 of fire-resisting material is seated upon the upper supporting ring 13 within the furnace casing. The diameter of the top ring is considerably larger than the diameter of the crucible, which readily permits of the crucible being placed within the furnace casing or removed therefrom without removing the top ring. A hopper 40 projects through the top ring, and has its lower end resting within the crucible. The upper end of the said hopper projects beyond the top ring, and is surrounded by an open-ended cylinder 41. The open-ended cylinder 41 is formed of fire-resisting material, and its connection with the top ring is made tight by means of wet sand or clay as at 41^a. A cover or top piece 42 is carried by the outer end of the cylinder, and is provided with a small central opening 43 through which the surplus heat and gases from the furnace fire escape. 50 indicates holes in the hopper and cylinder for the reception of suitable instruments with which the hopper and cylinder may be removed.

Trade Talk.

THE engineering works of Richard Moreland & Son, Limited, have been removed from Old Street, London, E.C., to Silvertown.

THE engineering business of Messrs. W. Hamnett & Son, 16, Longshut Lane East, Stockport, has been acquired by Mr. G. E. Lomas.

THE SPANISH CABINET have definitely decided to give the contract for the new naval squadron to the group of firms associated with Vickers, Sons & Maxim, Limited.

W. H. ALLEN, SON & COMPANY, LIMITED, are shortly starting the manufacture of water turbines under patents held by Messrs. Piccard, Pictet & Company, of Geneva.

MESSRS. MILLER & ROBB, 104, High Holborn, London, W.C., have been appointed London representatives of Messrs. T. Hackett & Sons, Eagle Tube Works, West Bromwich.

THE WARNER ENGINEERING COMPANY, LIMITED, have removed their offices from Dartmouth Street, Westminster, London, S.W., to 5, Carteret Street, Westminster, S.W.

SARGEANT, TURNER & SONS, LIMITED, Imperial Works, Lye, Stourbridge, have appointed Messrs. J. Petrie & Company, 99, Stockwell Street, Glasgow, as their Scottish agents.

THE brassfounding businesses of Pearson & Page, Limited, and Newton & Minchew, Limited, have been amalgamated under the style of Pearson, Page, Newton & Minchew, Limited.

MESSRS. J. & H. GREVENER, Eldon Street House, London, E.C., have been appointed sole agents in the United Kingdom and the English Colonies for Land and Sea Cable Works, Limited.

MESSRS. M. CRABTREE, J. CRABTREE, G. CRABTREE and S. L. CRABTREE, engineers' tool makers, Low Moor, Yorks, trading under the style of Crabtree Brothers, have dissolved partnership, so far as regards Mr. M. Crabtree.

J. J. HORROCKS & COMPANY, LIMITED, of Perth, who are now the agents in Victoria, Tasmania and South Australia for Hadfields' Steel Foundry Company, Limited have opened a branch office at 60, Queen Street, Melbourne.

WALKER BROS., LIMITED, of the Victoria Iron Works and the Staffordshire Galvanising Works, Pleck Road, Walsall, have established a London branch at 9, Bury Court, St. Mary Axe, E.C., under the charge of Mr. Edward Campbell.

MESSRS. KNOWLES & WOLLASTON have transferred to Graphite Products, Limited, of the Ticonderog Works, Queen's Road, Battersea, S.W., their contract for the sole agency for the Joseph Dixon Crucible Company, for Europe, Asia, Africa, and Australasia.

THE SWITCHGEAR COMPANY, LIMITED, have removed their head offices to Wilfred Street, off Sherbourne Street, Salford, Manchester. The company are not closing their Birmingham premises, however, which in future will be used for local purposes only.

GIBBONS BROS., LIMITED, of the Dibdale Works, Dudley, notify us that owing to the large increase in their business in recent years in the South of England, their Mr. E. A. Reed will, in future, be resident in London, at 168, Palace Chambers, Westminster, S.W.

A DISSOLUTION of partnership is notified in connection with Messrs. W. Blackmore, A. Howard, and C. Tazewell, engineers, etc., Bishopsgate-street Within, London, E.C., who traded under the style of Blackmore, Howard & Tazewell, so far as regards Mr. C. Tazewell.

THE Governors of the Imperial College of Science and Technology have decided, subject to the approval of the King in Council, to recognise the Metallurgical Department of the University of Sheffield as being in association with the Imperial College for the advanced study of the metallurgy of iron and steel.

AT a meeting of the members of Richards & Thompson, Limited, engineering and ironfounders, recently held at the Britannia Works, Caerleon, it was resolved and duly confirmed that the company be wound up voluntarily. Mr. C. G. Jolliffe, of Imperial Chambers, 70, High Street, Newport, has been appointed liquidator.

MR. A. S. MCCLELLAND, a director of the Steel Company of Scotland, the Dalmellington Iron Company, Limited, the Coltness Iron Company, Limited, James Dunlop & Company, Limited, and the Clydebank Engineering and Shipbuilding Company, Limited, died recently aged 74 years. The deceased gentleman was also associated with the business of McClelland, Kerr & Company, of Glasgow, and was exceedingly well-known in the Scottish iron and steel industries as a chartered accountant.

THE E. H. MUMFORD COMPANY, manufacturers of foundry moulding machines, Philadelphia, Pa., U.S.A., has in course of construction for one of the large steel plants a new 16-in. jolt ramming machine having a cast-steel table 6 ft. square, for the making of ingot mould cores, which, together with the rigging, may weigh up to 10,000 lbs. A smaller Mumford machine has been making copes for these ingot moulds for some time, and experimental work on the manufacture of cores by the jolt ramming process has been so satisfactory that it was decided to build one of sufficient size to take care of large work.

A MEETING of the British Aluminium Company, Limited, was held last month in London, at which it was decided to increase the nominal mortgage debenture stock of the company from £1,000,000 to £1,100,000, and to create and issue £240,000 5 per cent. redeemable mortgage debentures of the Loch Leven Water and Electric Power Company. It was stated that the pool of principal aluminium producers was now formally dissolved, with the result that the price of the metal, which had been as high as £200 a ton in 1907, fell to about £60 per ton, and the company would in future have to rely for satisfactory results not as hitherto upon a high percentage of profits, but upon the greatly increased sales.

MR. E. C. BROWN, who was with the late firm of Messrs. Herbert Cresswell & Company for the past 15 years, and who has started in business as Messrs. E. C. Brown & Company, iron, tinplate and metal merchants, Leadenhall Chambers, 4, St Mary Axe, London, E.C., has taken over all the agencies which they held, including the following:—The Aston Chain and Hook Company, Limited, Aston, Birmingham; the Crane Foundry Company, Limited, Wolverhampton; F. E. Martineau & Field, Limited, Birmingham, for patent-pressed steel and wrought-iron hinges, hasps, and staples, etc.; Wm. Oxley & Company, Limited, Rotherham, for "Park-Gate and Bull Dog Brands" of tool, drill, and spring steel, tyre bars, files, etc.; Wilcock & Jones, Limited, Rotherham, for iron and steel hoops, etc.; Thomas Shaw, West Bromwich, for axles, springs, bolts and nuts, and all descriptions of coach iron work; and Trotter, Haines & Corbett, Limited, Stourbridge, for gas retorts, furnace bricks, etc.

THE EMPLOYERS' PARLIAMENTARY COUNCIL have addressed a memorandum on the Trade Boards Bill to the President of the Board of Trade. This Bill, which is intended to establish wages boards for the fixing compulsorily of rates of wages which employers may legally pay, is objected to by the Employers' Parliamentary Council upon many grounds. It may fairly be assumed, the Council write, that the average rate of profit in the so-called sweated trades is not materially higher than the average rate of profit in trade generally. If it were so, capital would be attracted into the "sweated" trades until the rate of profit reached the normal level. There is abundant evidence to show that the establishment of a minimum wage, even when its observance can be secured, does not increase the total amount paid in wages, but simply causes a reduction in the higher rates of wages, the more competent workmen having thus to pay for the increased wages of the less competent.

Personal.

PROFESSOR PEDDIE has been elected hon. president of the Dundee Institute of Engineers.

MR. DOUGLAS VICKERS, Master Cutler of Sheffield, has returned from his trip to the East.

MR. J. H. B. NOBLE has been elected a director of Sir W. G. Armstrong, Whitworth & Company, Limited.

THE late Mr. William Hellewell, ironfounder, of Elmerdine, Gomersal, left estate valued at £11,652 gross.

MR. T. OGDEN, of Messrs. E. Keirby & Company, engineers, Rochdale, has been made a J.P. for the borough.

MR. L. J. BUSH, manager of the business of O'Connor, Limited, Wavertree Iron Works, Liverpool, was married last week.

THE value of the personal estate of the late Mr. J. Ritchie, engineer, of the firm of Messrs. Carrick & Ritchie, of Edinburgh, is £16,410 15s. 11d.

THE late Mr. J. Kirkman, J.P., steam packing manufacturer, of Park Place, 4, Park Road, Chorley, left estate valued at £23,068 gross, with net personalty £20,770.

THE gross value of the estate of the late Mr. F. Everitt, formerly a member of the firm of Allen Everitt & Sons, Smethwick, is £20,315 13s. 11d. and £20,247 11s. 9d. net.

MR. I. D. HENDERSON, a director of David & Wm. Henderson & Company, Limited, Glasgow, has resigned, to join Messrs. V. H. Coates & Company, engineers, 2, Norfolk Street, Strand, W.C.

MR. E. NETTLEFOLD, a director of Guest, Keen & Nettlefolds, Limited, has resigned in consequence of ill-health. Mr. G. Nettlefold has been appointed managing director of the company.

THE late Sir Philip Albert Muntz, Bart., deputy-chairman and senior managing director of Muntz's Metal Company, Limited, left estate of the gross value of £60,836, with net personalty sworn at £1,430.

MR. T. D. WEST has severed his connection with the Thomas D. West Foundry Company, of Sharpsville, Pa., U.S.A., and Mr. F. Tickner, of the Lackawanna Steel Company, has been appointed superintendent.

MR. JOHN LYLE, who recently retired from the position of works manager at the Uskside Engineering Works, Newport, has been the recipient of a presentation from the directors to mark their appreciation of his services over a long period.

THE late Mr. Alfred Dodman, of Swaffham, Norfolk, and of Dodman & Company, Limited, engineers, iron and brass founders, and boiler makers, of Highgate Works, King's Lynn, left estate of the gross value of £21,883, with net personalty £21,526.

LORD CHARLES BERESFORD, who, in November last, withdrew from the board of directors of Messrs. J. H. Andrews & Company, Toledo Steel Works, Sheffield, the step being deemed necessary owing to the receipt of a circular issued by the Admiralty, has now been re-appointed to a seat on the board.

MR. R. W. WORSDELL, nephew of Mr. Wilson Worsdell, chief mechanical engineer to the North Eastern Railway Company, has been appointed manager of the N.E.R. wagon works at Shildon, in place of Mr. G. T. Glover, who has been transferred as manager of the company's locomotive works at Gateshead.

MR. T. E. WATSON has been elected chairman of Mordey, Carney & Company, Limited. Mr. M. Mordey and Mr. J. H. Carney having resigned the position of managing directors, have been elected to seats on the board. Mr. John Lockhart has been appointed general manager of the company's business. Mr. Lockhart has previously held responsible managerial positions with Messrs. Workman, Clarke, and Messrs. Harland and Wolff, of Belfast, and was for seven years general manager for the Harlan and Hollingsworth Corporation in the United States of America, who have a very extensive business in shipbuilding and ship-repairing.

New Companies.

T. E. SMITH & COMPANY, LIMITED.—Capital £500 in £1 shares, to carry on the business of electric and mechanical engineers, etc.

THOM, LAMONT & COMPANY, LIMITED.—Capital £30,000 in £1 shares, to acquire the business of Lamont & Company, engineers, of Hawkhead Works, Paisley.

RENTON, HOLDSWORTH & COMPANY, LIMITED.—Capital £5,000 in £1 shares, to carry on in Sheffield or elsewhere the business of mechanical and electrical engineers, etc.

COOPER & COMPANY (OF HULL), LIMITED.—Capital £20,000 in £10 shares, to acquire the business of engineers, etc., carried on by W. Cooper, in Hull, as Cooper & Company.

LUKE AND FISHER, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of iron merchants, ironfounders, etc. Registered office:—8, Egypt Street, Warrington.

THE CASTINGS REPAIR COMPANY, LIMITED.—Capital £1,000 in £10 shares, to acquire the business carried on at Stillhouse Yard, Hunslet, Leeds, as the Castings Repair Company.

J. S. SMITH, LIMITED.—Capital £3,500 in £1 shares, to take over the business of a brass- and ironfounder, etc., carried on by J. S. Smith, at Parliament Street, Nottingham, or elsewhere.

LAKE TIME CHECK COMPANY, LIMITED.—Capital £1,000 in £1 shares, to acquire from F. G. Lake rights relating to patent No. 6,286 of 1908 for a machine for the registration of workpeople's time.

CARRICK AND RITCHIE, LIMITED.—Capital £20,000 in £1 shares, to acquire and take over as a going concern the business carried on at the Waverley Engineering Works, Edinburgh, by Carrick & Ritchie.

DAVID BUTTERFIELD (1909), LIMITED.—Capital £5,000 in £1 shares, to take over the business carried on by David Butterfield, Limited, incorporated in 1904, at the Central Iron Works, Park Street, Keighley.

H. S. HOLDSWORTH (LIMITED).—Capital £7,000 in £1 shares, to take over the business of a brazier, coppersmith, brass-founder and finisher, carried on by Mr. H. S. Holdsworth, at the Victoria Copper Works, King Street, Halifax.

T. YOUNG & COMPANY, LIMITED.—Capital £1,500 in £1 shares, to take over the business of brassworkers, stampers, piercers, etc., carried on by T. Young and W. C. Harner, at 6, Great Russell Street, Birmingham, as Young & Company.

GLAMORGAN CHEMICAL COMPANY, LIMITED.—Capital £2,000 in £10 shares, to adopt an agreement with T. H. Jones (trading as T. Herschel Jones & Company). Registered office: Glamorgan Chemical Works, Briton Ferry, Glamorganshire.

HEATON FOUNDRY COMPANY, LIMITED.—Capital £1,500 in £1 shares, to take over the business of engineers, ironfounders, and coppersmiths carried on as the Heaton Foundry Company, and to adopt an agreement with W. Henderson and W. Harrison.

GRAPHITE PRODUCTS, LIMITED.—Capital £15,000 in £10 shares (1,000 preference), to take over the business of dealers in graphite products, crucibles, lubricants, etc., carried on as Knowles & Wollaston, and to adopt an agreement with W. H. Knowles and G. W. Wollaston.

ANDREW & HARRISON, LIMITED.—Capital £1,500 in £1 shares (750 six per cent. cumulative preference) to carry on the business of producers, refiners, storers, suppliers and distributors of engineering and lubricating oils, boiler fluids, etc. Registered office: 36, Dale Street, Liverpool.

ANTI-RUST, LIMITED.—Capital £1,000 in £1 shares, to acquire a licence to be granted by the Coslett Anti-rust Syndicate, Limited, to adopt an agreement with

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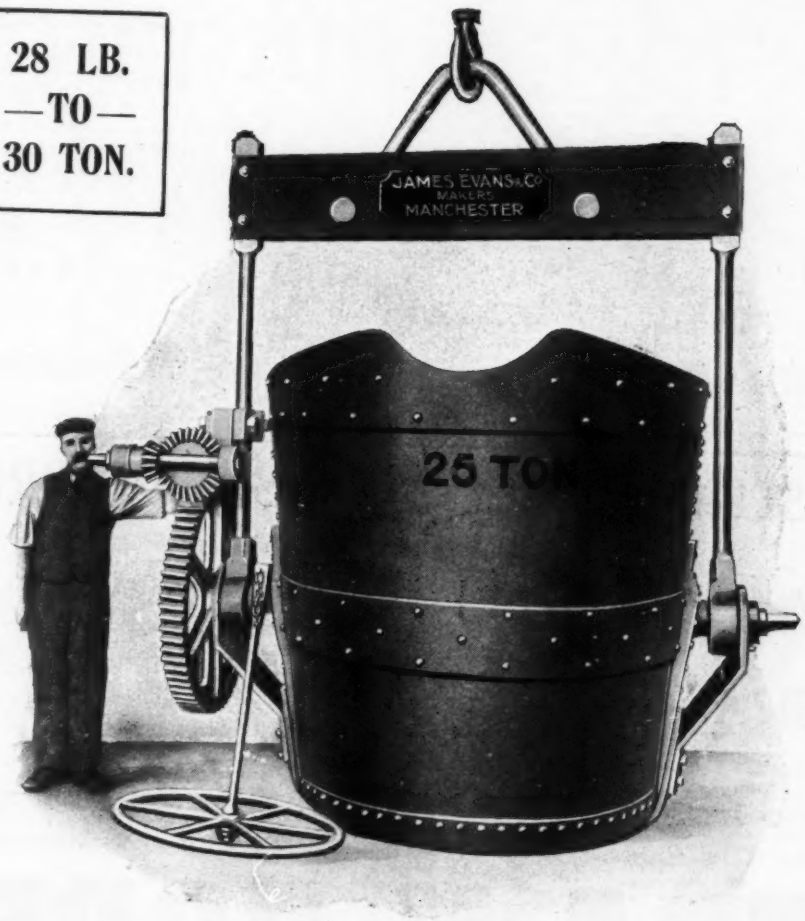

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W. T. Johns, and to carry on the business in connection with the licence. Registered office: 24c, Caledonian Road, King's Cross, London.

CARRICK & RITCHIE, LIMITED.—Capital £20,000 in £1 shares, to acquire the business carried on at the Waverley Engineering Works, Norton Park, Edinburgh, as Carrick & Ritchie, and to carry on the business of crane makers, etc. Registered office: Waverley Engineering Works, Norton Park, Edinburgh.

JOSEPH GREEN & NEPHEW, LIMITED.—Capital £4,000 in £1 shares, to take over the business of general and mechanical engineers carried on by J. G. Hirst at the Globe Iron Works, Crown Point Road, Leeds, as Joseph Green & Nephew. Registered office: Globe Iron Works, 3, Sheaf Street, Crown Point Road, Leeds.

GOSFORTH FOUNDRY COMPANY, LIMITED.—Capital £5,000 in £1 shares (1,000 preference), to acquire the business carried on at Dronfield, Derby, as the Gosforth Foundry Company, to adopt an agreement with W. Prestwich, and to carry on the business of manufacturers of and dealers in iron, steel, and other metals and minerals, etc.

METAL JOINTING COMPANY, LIMITED.—Capital £35,000 in £1 shares (15,000 preferred ordinary and 20,000 deferred ordinary), to acquire certain British patents, granted to S. S. Smith, T. Harden, and Amalgaline, Limited, for improvements in the jointing of cables, pipes, rods, etc., and to adopt an agreement with W. G. W. Barnard. Registered office: 71-2, Strand, W.C.

G. K. STOTHERT & COMPANY, LIMITED.—Capital £20,000 in £10 shares, to adopt an agreement with W. J. B. Coombe, and to take over the shipbuilding and engineering business referred to in the said agreement and in supplemental agreement between J. K. Stothert and F. E. Marshall (executors of the late G. K. Stothert) of the one part, and W. J. B. Coombe of the other part (being the business formerly carried on by the said G. K. Stothert at Hotwells Road, Bristol, as G. K. Stothert & Company).

Deaths.

THE death is announced of Mr. S. Mellor, Magnesium Metal Works, Patricroft, near Manchester, aged 76 years.

MR. W. SHARP, of Wm. Sharp & Sons, Limited, engineers, Camelon, Falkirk, died recently, aged fifty years.

MR. J. S. J. RAINER, of Messrs. E. R. & F. Turner, St. Peter's Iron Works, Norwich, died recently, aged 90 years.

MR. B. LIDDELL, son of Mr. J. P. Liddell, of the Canal Foundry, Newtown, Disley, near Stockport, died recently.

MR. J. DAWSON, of John Dawson, Limited, Lower Lane Iron Works, Milnrow, Rochdale, who founded the business some years ago, died recently, aged 67 years.

THE death occurred last month of Mr. E. Easton, the third and last surviving son of the late Mr. James Easton, founder of the firm of Messrs. Easton & Amos, engineers, of Southwark (now Messrs. Easton & Anderson). The deceased was 77 years of age.

MR. WILLIAM CAIRD, of Messrs. Caird & Company, shipbuilders and engineers, Greenock, died at Gourock recently, aged 58 years. He was for many years yard manager for the firm, but a considerable time ago he retired from active business.

THE death took place, on April 20, of Mr. Robert Hardman (79), founder and head of the firm of Messrs. Robert Hardman & Brothers, Rockcliffe Iron Foundry, Bacup, which was established in 1858, and last year celebrated its jubilee. Mr. Hardman was actively associated with the business, and his death came rather suddenly.

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27, Martin's Lane, Cannon Street, E.C.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From MOUNTFORD PHILLIPS & CO., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End Apr., 1909.	End Apr., 1908.
Iron—Scotch pig warrants ton	53/7½	*56/0
—Middlesbro' warrants .. ton	47 7½	51 6
—W.C. M/nos Bessemer ... ton	57 0	62 0
—Stock, Scotch ... ...tons	1,060	1,000
Copper—Chili bars, GMB ton	£57 5 0	£57 10 0
—Stock, Europe and afloat tons	—	23,702
Tin—English ingots ... ton	£134 0 0	£144 10 0
—Straits ... ... ton	£132 5 0	£143 0 0
—Stock, London, Holland, U.S.A., and afloat ...tons	—	13,362
Lead—English pig ... ton	£13 15 0	£13 12 6
Spelter—Ord. Silesian ... ton	£21 12 6	£21 2 6
Quicksilver (75lb)... bottle	£8 7 6	£8 4 6
Antimony—Regulus .. ton	£30 0 0–£31 10 0	£33 10 0

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 2 6	to	5 7 6
,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.	4 12 6	to	4 15 0
,, 18 to 24 in.	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 8s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 7s. 0d.; all per ton f.o.b., London. Copper (clean), £52 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £12 15s. 0d.; tea lead, £11 10s. 0d.; zinc, £17 5s. 0d.; all per ton delivered merchant's yard.

MESSRS. G. SWAINSTON & COMPANY, of Billiter House, Billiter Street, E.C., have been appointed London agents of H. & C. Grayson, Limited, Liverpool; Palmer's Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne, and the Tredegar Dry Dock and Wharf Company, Limited, Newport, Mon.

DARLINGTON is rapidly coming to the front as an excellent, cheap and convenient centre for manufacturing purposes. Last year the total rates were reduced by 4d. in the £, and a still further reduction of 2d. for the ensuing year is now announced, making the total rates for all purposes 5s. 2d. in the £. With the exception of one or two places where, in the absence of free library or baths, etc., the full municipal burden is not borne, Darlington will stand in the fortunate position of being the lowest rated amongst the municipal boroughs of the kingdom. The borough possesses exceptional advantages as a centre of manufacture in its excellent railway facilities, abundance of cheap labour, low rating, and electric power on easy terms. We understand that the North-Eastern Railway Company have recently purchased a large amount of land at Darlington which they are utilising for the purpose of adding to their already extensive engine shops, and that it is their intention to remove to Darlington from Gateshead at an early date the offices of their chief mechanical engineer (Mr. Wilson Worsdell).

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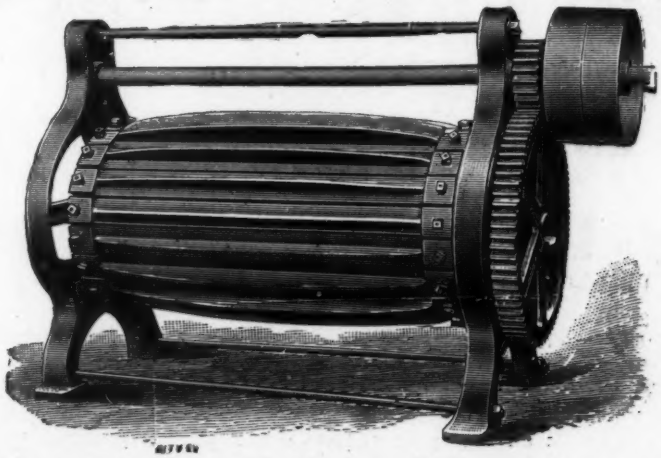

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Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Jackman, J. W., & Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

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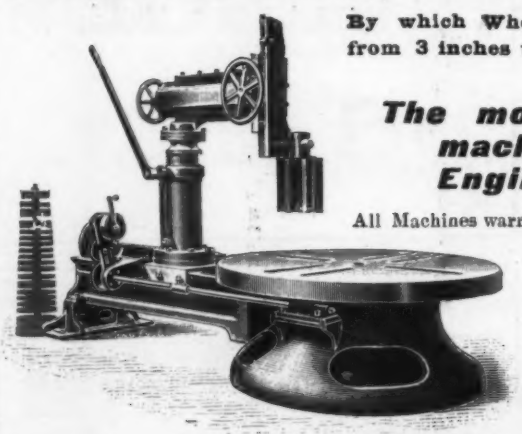

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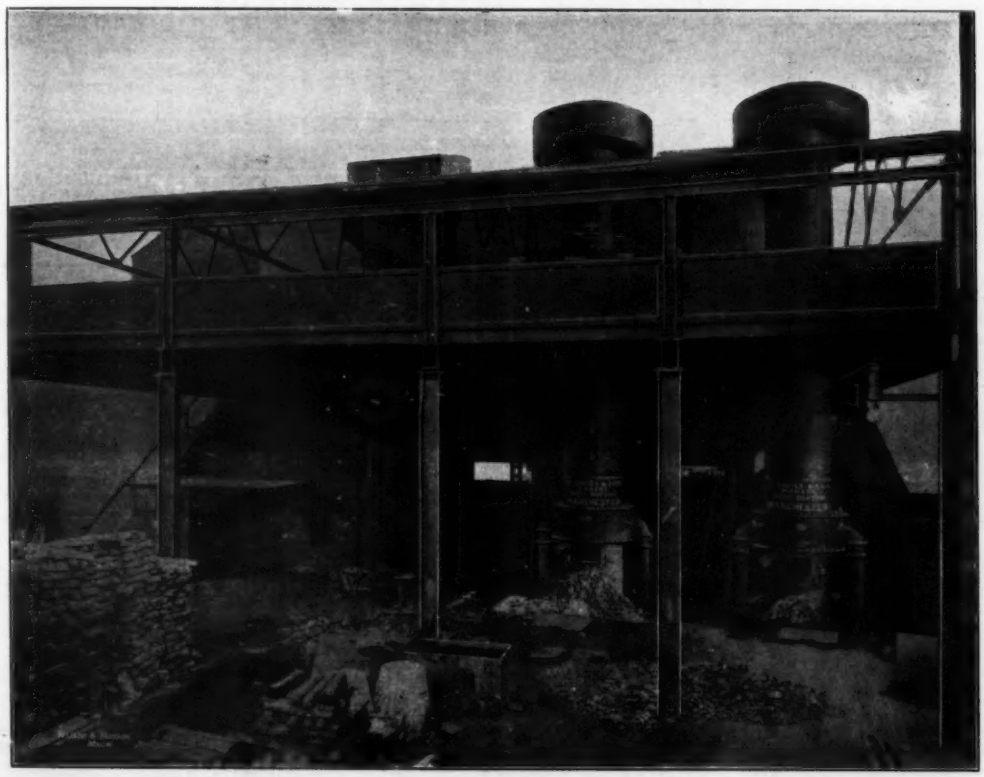

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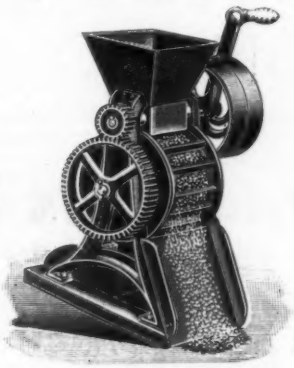

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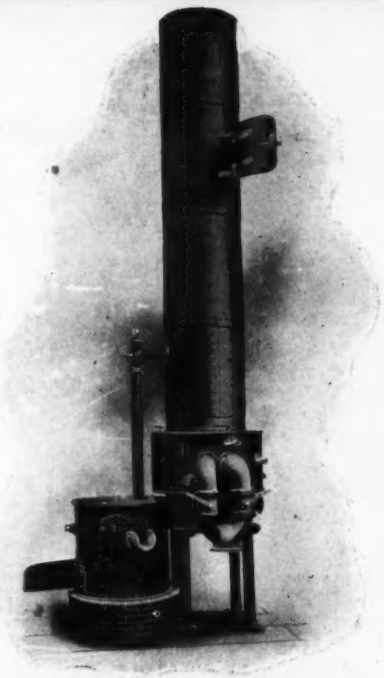

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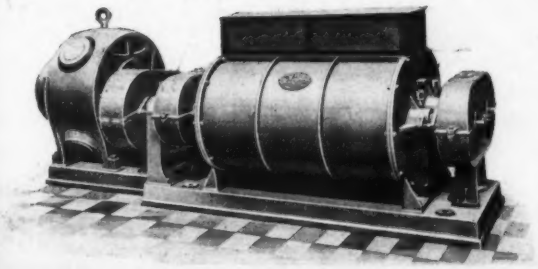

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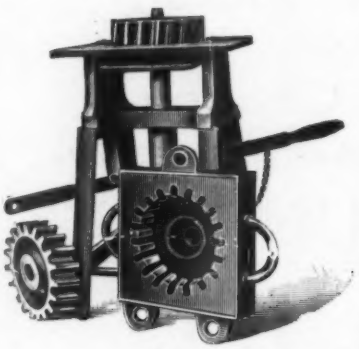

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